Document Title: A Randomized-Trial Evaluation of a Law Enforcement Application for Smartphones and Laptops that Uses GIS and Location-Based Services' to Pinpoint Persons-of-Interest

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ABSTRACT

This report summarizes a project that developed, implemented, and evaluated a GIS-enabled application that dynamically identifies the location of persons of interest, such as gang members, sex offenders, parolees, and so on. The application, called P3i, is designed for use by law enforcement officers. P3i pushes the location data to officers' smartphones, tablets, and MDT (mobile display terminal)/laptops.

A randomized evaluation was conducted with the Lincoln (Nebraska) Police Department (LPD). Officers (N = 90) were randomly assigned to one of five GPS-enabled devices or a no-P3i, control condition. Over a six-month period, 75 treatment officers were compared to the 15 control officers on a variety of productivity measures as well as to officers' prior year's performance. Measures included citation arrests, warrant arrests, and information reports. We also collected self-report data from surveys asking officers about the duration, frequency, and intensity of their use of the technology.

Analyses provide some evidence that officers who used the P3i application on GPS-enabled devices were more productive than controls and more productive than they had been during the prior year. Follow-up analyses suggested a variety of individual difference factors (e.g., high performance officers in 2011, low performance officers in 2010, males) also were correlated with increases in productivity.

In focus group discussions with a subset of the officers in the study, the officers expressed great enthusiasm for the P3i application and their use of new mobile technologies in general. The officers had many suggestions for improvements and provided insights into how they specifically used their devices and P3i.

A cost-benefit analysis suggested that implementation of the device results in a savings of around $800 per officer, assuming a five-year device life and 7% interest rate. Additional assumptions considering different economic and technical scenarios were also developed and reported, but the results remained basically positive except for iPads, only have positive net benefits when there are no usage costs, while other devices have positive net benefits in almost all cases.

In order to better understand officer adoption of P3i as well as their use of smartphones and tablets for work purposes, the project also examined what might account for the use of technology. Consistent with other studies, we found performance expectancy, a belief that the application would aid the participant in the performance of his or her duties, had the primary, significant effect on P3i usage.

Thus, this study supports the position that if technology is made available, and officers have a reasonable expectation that it will help them in their work, they will utilize the technology. Further, if that technology actually can help them in their efforts, it is likely that the increase in productivity can be measured and captured. Our project also shows, however, that it may be difficult to find sensitive measures that will capture increases in productivity. One problem that can be anticipated is that outcomes are multi-determined, and thus it can be difficult to find measures that will be sensitive to positive impacts because of the multiple causes for the effects in which we are interested.

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EXECUTIVE SUMMARY

As electronic and smartphone technologies continue to evolve, it will be critical for the law enforcement community to successfully integrate geospatial technology into mobile devices using Global Position Systems (GPS) capabilities. The technology future is here, and police need to effectively utilize these technologies as they become relevant for law enforcement.

The effective utilization and integration of computer-based technology has been understood for decades as critical for modern policing. Computer-based technologies taking advantage of Geographic Information Systems (GIS) have been used by police departments to visualize the location of crime events and addresses of persons-of-interest stored in a centralized database on a digital map, and to model crime patterns for criminal activity prediction, among other outcomes. In the last decade, GIS also has been used by police to create density or cluster maps known as "crime hot spots" using retrospective reports of crime activity in a particular geographic area (i.e., census block groups, police districts, zip codes, neighborhoods). This practice has allowed crime pattern modeling for criminal activity prediction, evaluation of crime risk, crime suppression, and the deterrence of offenders, among other applications.

Devices that utilize GIS and GPS have the potential to make the geographic space available on a real-time and dynamic basis when integrated with open source geospatial mapping software. Moreover, location-based services (LBS), information services delivered by mobile devices (i.e., smartphones, tablets), use the mobile network and its location obtained by the built-in GPS unit. One potential development is the integration of GPS technology and mobile devices into a location-aware service that can be seamlessly incorporated into the daily operation of police officers.

However, even if there is a successful integration, will officers use it effectively? What predicts whether officers will adopt new technologies such as GPS-enabled devices? The law enforcement community has taken less advantage of GIS/GPS technologies than might be anticipated. This lack of adoption of technologies is regrettable: Studies have shown that contextual information provided in real time to police officers help them make better decisions while working in the field, such as acquiring additional information from an individual who has committed a traffic violation but has criminal records for dealing drugs, or avoiding traffic congestion that otherwise may have prevented an officer's timely arrival to an incident. Some of the advantages in using LBS technology in law enforcement are that geographic coordinates of contacts made by officers about persons-of-interest (POIs) can automatically be stored in a centralized database allowing geo-statistical analysis to better predict the appearance of crime. Additionally, the mapping display and searching tools (i.e., by specific address and name of POI) can be activated by a voice command which frees up the normal multitasking activities that an officer performs during patrolling activities increasing his or her situational awareness and safety, along with improving tactical decision-making process. Police officers can also request information about crimes that occurred near the target location and add different layers of information such as premise history and known hazards in the neighborhood, among other inputs. Police officers may also have the opportunity to write contact reports for individuals and instantly update the records management system without the need to physically be at the police station.

A barrier for effectively utilizing any new technology is lack of interest or ability of the potential user. Social scientists have been studying the circumstances under which individuals adopt new technologies. Are the factors that explain use of technology in the police context the same ones that explain technology uptake in other contexts?

In this project, we developed a GIS/GPS system that dynamically updates the spatial coordinates of people- and events-of-interest and push that location information to officers as they move around on foot or in their automobiles. Our application, called P3i, accesses police departments' crime databases and projects selected data on electronic maps (via Automated Vehicle Location (AVL) systems), dynamically identifying the location of persons of interest – such as gang members, sex offenders, and parolees – on smartphones, tablets, and MDT (mobile display terminal)/laptops. See Figures 1 and 2, below.

Figure 1. *Actual screenshot from P3i*
(as would be viewed by officer on each of the devices)

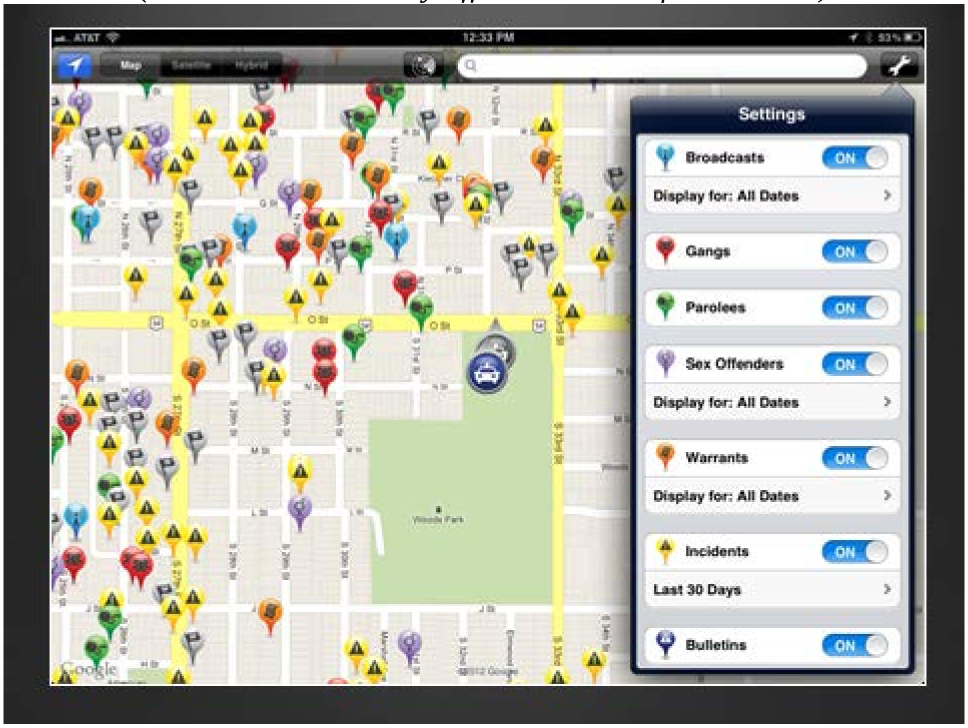
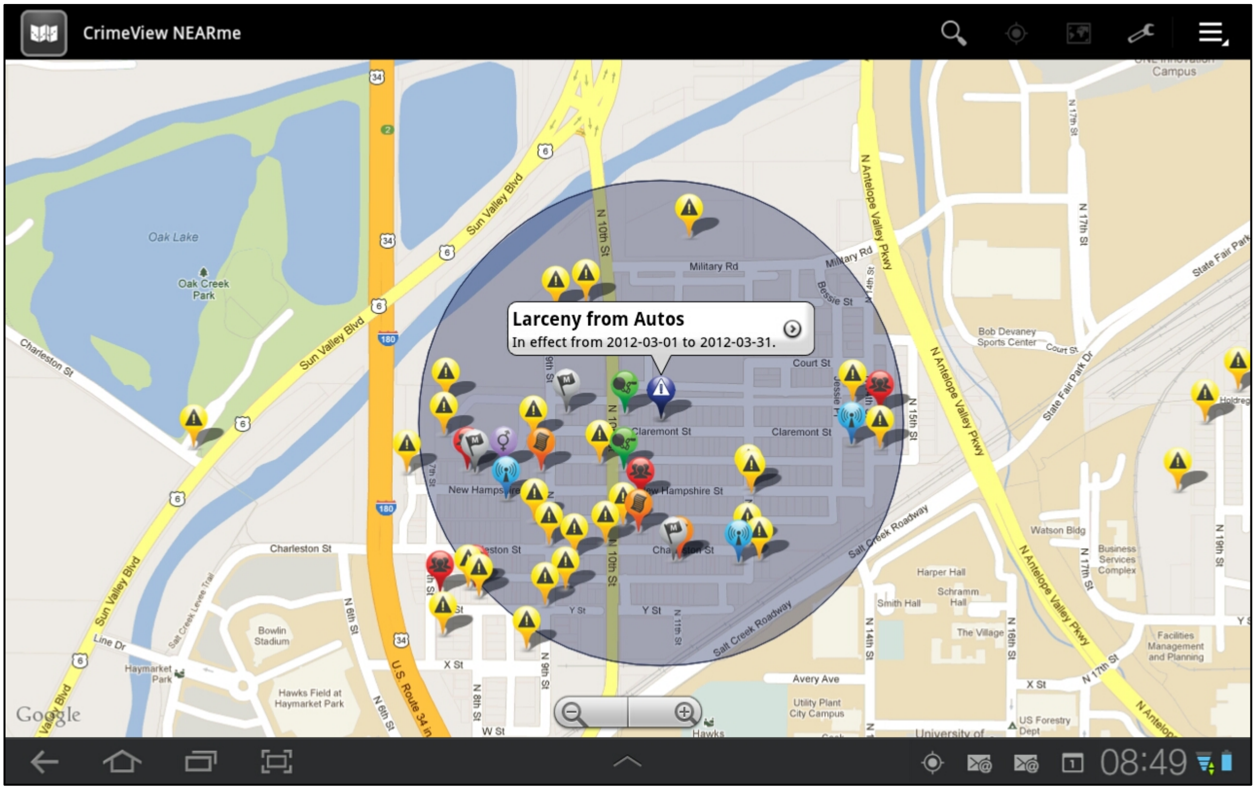


Figure 2. *Clicking on icon brings up crime-specific information*



We conducted a randomized trial with the Lincoln Police Department to assess P3i's potential value. We wanted to determine not only whether there were policing benefits that accrued from introducing smartphones, tablets, and LBS technology to the Lincoln Police Department, we also wanted to assess the economic benefits versus the costs of using the technologies. In our police-impact evaluation, we looked at typical officer productivity measures: citation arrests, warrant arrests, and information reports. We also determined costs under a variety of assumptions/scenarios, and we calculated how the costs balanced against potential economic benefits. Finally, we also examined what social scientific perspectives explain whether Lincoln police officers used P3i.

Participants and Conditions

All 263 patrol officers in the Lincoln (Nebraska) Police Department (LPD) were eligible to participate. Ninety officers were randomly selected, using a random number generator to select from a list of all LPD patrol officers, and invited to participate in the project.

We assigned the 90 Lincoln Police Department (LPD) officers to one of six groups:

- Group 1. A control group of officers was identified who would not use the P3i technology in any form, but their work outcomes would be monitored.
- Group 2. Fifteen officers assigned to use P3i via car-based laptops, specifically Mobile Data Terminals (MDT) equipped with aftermarket, GPS hardware. Their work outcomes would be examined, and they would be invited to respond to surveys and participate in focus groups with the researchers.
- Groups 3-6. Sixty officers randomly assigned to use one of two phones (Apple or Android) *or* one of two tablets (Apple and Android). Given the proliferation of portable devices, we wanted to determine if Apple or Android products and if tablets or smartphones were preferred. These 60 officers would have their work outcomes examined, and they would be invited to respond to surveys and participate in focus groups with the researchers.

Treatment officers (Groups 2-6) were assigned to 1 of 18 training dates between May 3 and July 24, 2011. In these trainings, the officers were taught, if needed, how to operate their device, and they were all taught how to use the P3i application.

The random sample of 90 officers was primarily male (87%), with an average age of 34.4 years (*SD* = 7.81, range = 22 to 58). There were no differences in officers' rank. A random assignment check indicated there were no meaningful, pre-existing differences among officers across the groups.

Measures

Each officer was followed and relevant police data (arrests and information reports) collected for six months subsequent to his/her training on the use of P3i (evaluation period). We examined *citation arrests, warrant arrests, and information reports* during this six month period, and we compared arrest and information reports from the year prior. Finally, we collected *self-report* data from surveys we administered asking officers about their use of the technology during the evaluation period. Officers were asked to report the duration, frequency, and intensity (DFI) of their use of the software and hardware, one month (T1) and six months (2) after training.

Quantitative Results

There were significant differences between officers in the control group and the five treatment groups related to citation arrests and warrant arrests. On average, officers in the treatment groups had more citation arrests per month (8.24) than officers in the control group (6.80), a statistically significant difference, and officers in the treatment groups had more warrant arrests per month (1.57) than officers in the control group (1.22), a statistically significant difference. There were not statistically significant differences across devices.

For information reports, the data reveal more treatment officers had more information reports per month (2.09) than control officers (1.39), a statistically significant difference. In total, treatment officers filed more total information reports on average (M = 16.18; SD = 11.52) than controls (M = 8.33; SD = 7.73; $F(1, 87) = 6.34$, p = .01). We compared each of the experimental groups to the control officers. Post-hoc analyses revealed significant differences for most experimental groups versus control. Droid, iPad, and Xoom users filed significantly more total information reports than control. iPhone users were only marginally higher and MDT/laptop users were not statistically different from the control officers; however, both groups filed considerably more reports numerically.

Treatment groups had more warrant and citation arrests in 2011 than the control group; however, there were no differences compared to 2010. We tested for differences in productivity from 2010 to 2011 using information reports. In 2010, information reports were exclusively submitted via the record management system (RMS), but in 2011 officers had the additional portal of submitting via the P3i system.

A paired samples *t*-test comparing 2011 reports to 2010 for the five treatment groups revealed a significant mean difference such that on average in 2011 (after the implementation of P3i), *officers filed more reports* ($t(70) = 3.90$, $p < .001$). In order to better understand any potential differences across officers, we re-tested the mean differences specifically for high and low performers (identified using a mean split of information reports at 2010 or 2011), gender (male or female), young or old (identified using a mean split of age), and relatively new or old officers (identified using a mean split of years of service). The mean difference remained significant (with a higher value for 2011) for officers below the mean of performance in 2010, above the mean of performance in 2011, males, both younger and older officers, and officers below the mean number of years of service. However, high performers in 2011, low performers in 2010, and officers above the mean of years of service did not significantly change across time suggesting no effect of P3i for these individuals.

Although these findings suggest the efficacy of the system for most officers, they do not necessarily mean that the system was the mechanism for the increase (e.g., the officers most responsible for an increase in productivity may have been those who used the system least). In order to shed some light on this question, we computed a change score for information reports such that positive scores indicate increases in information reports over time and negative scores indicate decreases over time. We then correlated this change score with self-reported system usage (DFI) at T1 and T2. T1 DFI was significantly related to change in information reports, $r(75) = .25$, $p = .03$, while T2 DFI was not, $r(63) = .20$, $p = .11$. Importantly however, the small sample size and moderate effect size ($r = .20$) suggest that the lack of significance at T2 may be a result of sample size. Even so, the effect was smaller than at T1 ($r = .25$), suggesting that officer's early report of their system usage was most related to changes in productivity.

Analyses of technology adoption measures (DFI) indicated officers' expectancy of how well the technology would help them in their work (performance expectancy) was the most significant predictor of P3i use. Social influence joined performance expectancy as a predictor of use in T2. Contrary to our expectations, officers' relationships to the police department as an entity did not play a role in their decision to use P3i.

In testing the relationship between self-reported use and actual use (as measured by information reports), we found a non-significant relationship of T1 self-reported use to the following years' use. However, the T2 self-reported use was related to actual use. One explanation for this result could be that information reports were not a good proxy for actual use. That is, information reports did not fully capture actual use of the system, or that officers needed time to adapt to the application in order to later use it to file information reports. Other actual measures of use, such as the number of hours the application was activated or some other measure were not available, but could have been superior proxies for use.

Qualitative Methods and Results

Focus groups were conducted with members of the five treatment groups. Two rounds of focus groups were conducted, first near the beginning of the deployment of P3i (n = 24) and after six-months of P3i usage (n = 14). Results indicate the officers who participated in the focus groups were very positive and enthusiastic about P3i, and offered some valuable insights. Because the participants in the focus groups may have been those officers more satisfied with the mobile devices and the P3i application, the results of our focus groups do not necessarily reflect the views of all (n = 75) the Lincoln officers who were assigned devices loaded with the P3i application.

Mode of operation. Most of police officers in the focus groups mentioned that they use the software before patrolling their geographic area. Some police officers indicated they would start their shift by driving to a parking lot, and then retrieving P3i data. When needed, officers might pull over to check for some specific POIs. Police officers valued the fact that they can "tailor" the software according to their own needs, filtering out specific POIs.

Technical issues. Overall, police officers found that learning to operate the software was very simple. Other police officers valued the fact that the application was simple to operate without feeling overwhelmed by the information provided by P3i.

Police officers liked the graphic aspects of the P3i software, especially the "bubbles" showing POIs. Having software that could give them an overall idea of the criminal situation of the city, not just tabular data, but adding the geographic dimension of it, was highly valued. One police officer observed, "You know that all of these people and situations are out there, but you don't think about it until you see all the bubbles… or you don't think it's your problem because it was someone else's case." Many officers mentioned having a visual display of POIs helped them to get a better idea of criminal activities in the city.

A limitation of P3i that came out during focus groups was that Android phone users indicated that they often encountered technical difficulties in getting P3i to operate on their devices. It is our belief that the older version of Android (2.3), and the processing power of the hardware (Motorola Droid2), were less than ideal for this application.

iPad users liked the size of the screen since allowed police officers to be more comfortable in filling out reports. It is "[n]ice having the iPad when doing reports because of the bigger screen size," reported one officer. The opposite was mentioned by an iPhone user: The "iPhone screen is too tiny to go back and forth between RMS and P3i." In general, tablet users liked the screen size of their devices, in comparison to the smart-phone users who mentioned more limitations when interacting with P3i due to smaller screen sizes.

Efficiencies and effectiveness. Police officers felt that using the software made them more productive as they have access to current information for their daily operations. One police officer mentioned: "Almost forces you to be proactive when you're driving around …." Others said: "When you have that much information at your fingertips it is very easy to be proactive in your downtime," and, "With all the information you have, you feel more like you are not wasting your time."

Police officers mentioned that they preplan their daily activities using the software so they can make better decisions on how to use their time more efficiently and more effectively. In the opinion of one police officer, pre-planning using the software also increases safety: "You know whether or not you should be thinking about calling for backup before you go in." P3i has been useful when patrolling areas of the city at night, especially in new or isolated urban areas, providing extra protection to police officers. Also, when police officers visit an apartment complex, they can retrieve information from many households at once, providing useful information of what or who else is there, therefore increasing their feeling of being safe.

Efficiencies identified by the officers were related to the fact that police officers do not necessarily need to go back to their substations to retrieve information from POIs, print documents, and then go back to their original location. By collecting data through P3i, and then connecting that data with the RMS, trips to the substations decreased as police officers access information directly from the RMS.

Impact on social interactions and the potential "big-brother" effect. Researchers have reported that when MDTs were installed in patrol cruisers, it adversely affected officers' social lives, since they had less time to share with their peers at the substations. During the focus groups, the question was posed about whether the use of the technology negatively impacted the officers' relationships with fellow officers. The Lincoln officers responded the use of P3i has not affected their social lives with other peers or their interacting at substations.

Some police officers considered whether the "big-brother" effect of having a device that could track their geographic positions 24/7. While potentially troublesome, the benefits of having the software with them outweighed potential negative effects. One police officer observed, "The big brother aspect is a little intimidating, but knowing where everyone is and who is out there – makes it a bit safer, especially in a situation where you could not get to your radio. If you get knocked out, folks will know where you are." Another police officer mentioned that "if they [management] start using it for discipline, officers are just going to flat out not to use it."

Changes in motivation. All police officers in the focus groups mentioned that the software did not make them more motivated; rather they mentioned the software, along with their other devices they carry, was another useful tool for their daily activities. One officer mentioned it was “satisfying to know that you are closing cases,” but the motivation level was the same, observed the officer.

Practical applications and benefits. Officers mentioned P3i has been useful when cases of sexual assault or indecent exposure have occurred in the city, as they could retrieve information of known sex offenders located nearby. This process expedited the search and recognition of suspects by the victims.

In the field, police officers have been able to identify persons of interests without IDs by looking up addresses in P3i and displaying their mug shots. This has resulted in arrests that otherwise would have not occurred without the assistance of P3i.

One police officer mentioned how much the use of P3i has affected the job: “I would say that contact with people has gone up by maybe 50% …. [I] try to make a couple of contacts on warrants each day.” By increasing the number of contacts with POIs, it has also impacted law enforcement outcomes, with one police officer indicating making “five arrests in about one hour on one shift in particular!”

Operational recommendations. Many police officers indicated that it would be more efficient if P3i was available on multiple devices when patrolling. They would prefer a tablet or an MDT when they are in the patrol car, but use another device (e.g., smartphone) when they leave the car. Other police officers mentioned that having an iPad acting as an MDT would be beneficial: “If iPad had a keyboard and you used that as MDT, that would be great.” Another officer added: “If the tablet was in a bracket in your cruiser instead of MDT and you had the phone for portability – that would be awesome. Plus, if you could mount the tablet, it would be less distracting than setting it in the passenger seat.”

Police officers were asked if they would recommend P3i to others. All police officers made positive comments about the application: "Yes, absolutely. Feel more informed. It gives personal satisfaction." Another was equally enthusiastic: "I would recommend this [P3i] to another officer – no questions asked." Most police officers commented they would like to keep their devices after the research ends.

Technical recommendations. Several officers mentioned that they would like to add the latest date and number of contact attempts with POIs that have been made above the graphic pins ("bubbles"), so they could decide whether or not a new contact attempt should be conducted. Police officers also mentioned that symbols (i.e., pins depicting different kind of POIs) were not very effective since they were difficult to differentiate by size or color.

Other police officers suggested that changes are needed to the "Filing Report" feature. Problems included it lacking a "back" button to make changes, or allowing one to quit and start from the beginning without "having to go through all of the questions to get out of there."

Cost-Benefit Analysis

Economic analysis indicated that the solution also results in saving cost of about $800 per officer, using standard cost-benefit assumptions. In police departments with thousands of police officers in their workforce, total savings can be substantial, especially when considering budgetary constraints, without jeopardizing public safety by keeping a more proactive and effective workforce in the field. It is also important to consider that the P3i technology can be installed in most devices that police officers already have for their personal use; therefore, it is expected that indirect saving costs for police departments may be even greater. Assessing costs and benefits under different scenarios does result in benefit estimates ranging from a positive $601 to a negative $310 depending on the cost of the device, monthly usage charges and the life of the device. The original cost of the device has a significant impact in the resultant present discounted value (PDV) net benefits. Thus, PDV net benefits are $300 lower for iPads ($500 cost) when compared with the average costs of the other devices ($200). Usage costs can also have a significant impact on the present discounted value of the net benefit. Finally useful life matters in that it allows a longer time to generate benefits from the initial costs. Cumulatively, the results show that iPads only have positive net benefits when there are no usage costs, while other devices have positive net benefits in almost all cases.

Discussion

The quantitative results provided evidence of some increased productivity for officers using the P3i mobile application, and suggested a variety of individual difference factors (e.g., high performance officers in 2011, low performance officers in 2010, males) were also related to increases in productivity measures. The cost-benefit assessments showed the benefits of using mobile devices equipped with the P3i, LBS application outweighed the costs of buying the hardware and software required to operate the GPS/LBS technology. The use of P3i was driven by officers' expectations of how well the technology would assist them in their work.

Thus, our study supports the position that if technology is made available, and officers have a reasonable expectation that it will help them in their work, they will utilize the technology. Further, if that technology actually can help them in their efforts, it is likely that the increase in productivity can be measured and captured.

Our project also shows, however, that it may be difficult to find sensitive measures that will capture increases in productivity. One problem that can be anticipated is that outcomes are multi-determined, and thus it can be difficult to find measures that will be sensitive to positive impacts because of the multiple causes for the effects in which we are interested.

The qualitative data provide another avenue of understanding possible impacts. In our study, officers participating in the two focus groups were almost universally enthusiastic about the technology. Officers confirmed liking to use the technology, and that enthusiasm was not dampened even by the early problems with P3i on Android devices.

Overall, then, the evaluation supports the notion that location aware services in mobile platforms are cost-effective and can improve operations in law enforcement. Officers enjoy using the technology, and if the technology can be reasonably expected to enhance officers' performance, they are likely to use the technology.

Introduction

The effective utilization and integration of computer-based technology has been understood for decades as critical for modern policing (Chan, 2001; Manning, 1992), and one of the most promising of these technologies is Geographic Information Systems (GIS) (Leipnik & Albert, 2003; Leitner, 2013; Pica & Sørensen, 2004; Ratcliffe, 2010). GIS has not only revolutionized applied and theoretical geography, creating a new discipline (GIS science) and spawning research in visual analytics and data mining, GIS also has revolutionized the way many organizations deal with the information stored in databases by adding the geospatial dimension (Devillers, Bédard, & Jeansoulin, 2005). Geospatial technology also has evolved to satisfy the demand for new analyses and applications. GIS has meant a more efficient and multidimensional spatiotemporal method to describe and understand the interactions and interrelations between humans and their inhabitable spaces; in addition, GIS has democratized the world, allowing people to have access, interpret, and manipulate geographic information (i.e., land use, topographic analysis, land cover changes) that in the past was only available to the scientific community (Dunn, 2007; Kingston, 2011; Pickles, 1995). “Participatory GIS” (also known as PGIS) has been used to improve socioeconomic and environmental conditions, increase the efficient allocation of resources, and alleviate human stressors (i.e., crime, famine, natural disasters, migration). For example, after the earthquake devastated Haiti in January 2010, hundreds of GIS volunteers located on the epicenter collected geospatial information of people’s needs and local site conditions, which allowed for a swift transfer of critical geospatial information to emergency responders, resulting in faster and more accurate decisions (Clark, Holliday, Chau, Eisenberg, & Chau, 2010). GIS tools have long been seen as beneficial to any organization for which mapping can be crucial (law enforcement, fire departments, emergency units, homeland security, etc.) (Harries, 1999).

GIS can be used by police departments to visualize the location of crime events and addresses of persons-of-interest stored in a centralized database on a digital map, and to model crime patterns for criminal activity prediction, among other outcomes (e.g., Streefkerk, van Esch-Bussemakers, & Neerincx, 2008). In fact, by careful planning of geographic boundaries, it is possible to reduce total response distances and increase the number of incidents per geographic units (Curtin, Hayslett-McCall, & Qiu, 2010). Spatial perceptions of crime have been mapped and georectified to influence police decisionmaking for unreported crime activity by citizens using GIS (Lopez & Lukinbeal, 2010). In the last decade, GIS also has been used by police to create density or cluster maps known as “crime hot spots” using retrospective reports of crime activity in a particular geographic area (i.e., census block groups, police districts, zip codes, neighborhoods). This practice has allowed crime pattern modeling for criminal activity prediction, evaluation of crime risk, crime suppression, and the deterrence of offenders, among other applications (Kennedy, Caplan, & Piza, 2011). Research incorporating the consideration of opportunity structures for crime (Cloward & Ohlin, 1961) and routine activity theory (Cohen & Felson, 1979) have shown that crime places are located in much smaller and specific geographic areas of the community, or micro clusters, such as street blocks, specific addresses, or buildings, and that the spatial distribution of crime incidents in these micro places are stable over time (Bursik & Webb, 1982; Weisburd, Morris, & Groff, 2009). Studies conducted by Sherman, Gartin, and Buerger (1989) and Weisburd and his colleagues (2009) have shown that over 50% of crime incidents come from 3% to 5% of addresses in urban places.

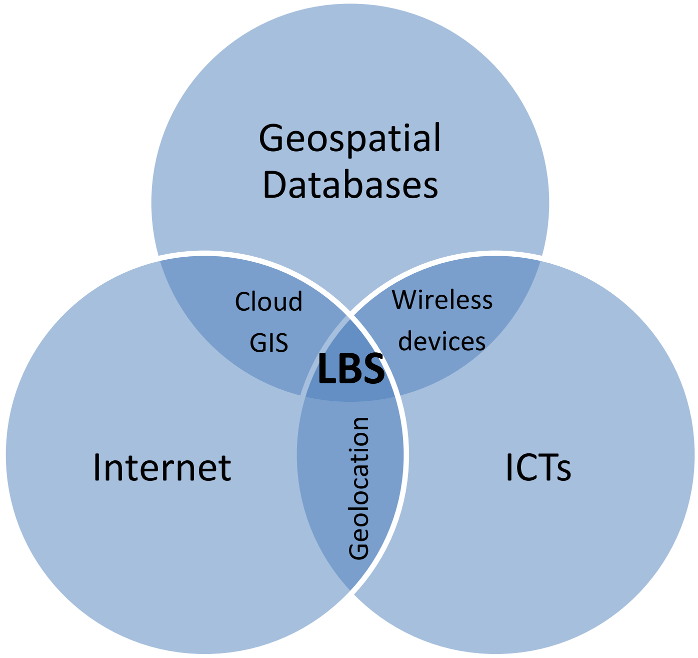
According to Caplan and Kennedy (2010) the models used to predict crime hotspots are limited as they do not include in their analysis variables such as the "social and structural contexts in which crime occurs" (p. 7). Kennedy, Caplan, and Piza (2011) argue risk models can become extremely complex especially when a police department has many data layers, as it is difficult to define which data layers fit the best prediction model. Crime is a very complex spatial and sociological phenomenon that requires sophisticated modeling and the right set of geographic and non-geographic variables to make predictions reliable (Ratcliffe, 2010; Sampson, 2011).

To overcome limitations in analyzing crime clusters, researchers have developed new empirical and theoretical based-models such as risk terrain modeling (RTM) to improve crime analysis forecasts and thereby making policing operations more efficient. RTM is not based as much on past incidents depicted on a density map as traditional cluster analysis, but rather uses the interconnected physical, social, and behavioral components of crime. Thus, the model gathers information from current suspects and offenders (i.e., demographic characteristics), uses empirical evidence obtained from incident reports (i.e., type of crime, modus operandi, time of the offense), conducts spatial risk assessments according to the local physical characteristics of the geographic space (i.e., presence of bars, schools, etc.), and adds evidence-based strategies from police data to forecast where crime will occur. RTM has been shown to be more accurate than retrospective hotspot mapping for forecasting future crime occurrences, and it has successfully been applied to evaluate the likelihood of street muggings, residential robberies, and aggravated assaults, and it also has been used to evaluate the adequacy of police resource allocation (Kennedy et al., 2011).

The complexity of crime may explain why, despite technological and analytical mapping developments in the last few years, police agencies still seem reluctant to embrace them: Crime seems to be inherently dynamic. It is difficult for many police officials to comprehend how complex social forces can be “captured” using mapping techniques. Not surprising, then, new spatial forecast crime analyses/modeling has not been rapidly adopted by law enforcement (Caplan, Kennedy, & Miller, 2011; Weisburd & Lum, 2005). Nonetheless, geography has become the center piece for a new wave of researchers, and empirically-based applications that are easily accessible for law enforcement users are emerging. Some expect that web-based and mobile devices will be incorporated into routine police operations (Streefkerk et al., 2008). To date, though, mostly GIS tools for police use have been adopted in larger metropolitan areas (Weisburd & Lum, 2005).

GIS hardware like Global Position Systems (GPS) devices have the potential to make the geographic space available on a real-time and dynamic basis when integrated with open source geospatial mapping software (e.g., Goodchild, 2009; Tsou, 2004). Moreover, location-based services (LBS), information services delivered by mobile devices (i.e., smartphones, tablets), use the mobile network and its location obtained by the built-in GPS unit. LBS have been described as an intersection of technologies (Brimicombe, 2002; see also Kim, 2011), in particular information and communication technologies (ICTs), mobile telecommunication networks, location-aware technologies, and handheld devices in connection with the Internet, GIS, and geospatial databases (Figure 1).

Figure 1: *LBS intersection of technologies* (adapted from Brimicombe, 2002).



This new configuration of network attributes, wireless telecommunications and geospatial information through built-in GPS capabilities makes the user of a wireless device an active member of the system, the user leaves behind a geographic-print of spatial movements and tasks that can be recorded, tabulated, analyzed, and then delivered back to the user to make better, informed decisions. Thus, LBS seamlessly integrates GIS, GPS and satellite remote-sensing technologies through mobile networking systems and therefore can be considered a specialized GIS (Shiode, Li, Batty, Longley, & Maguire, 2002; Virrantaus, Markkula, Garmash, & Terziyan, 2001) and represents a revolution for many aspects of human activities (Castells, 2005, 2010; Kalkbrenner & McCampbell, 2011). For example, consider how LBS is routinely used by millions of people around the globe: Getting directions from point A to B on a map according to the current location, getting information about the local weather, finding the closest gas station, or trying to find the closest Starbucks within a 2 mile radius using a cloud application such as Google Maps (Casady, 2011a). The gas station and the coffee shop represent points in geographic space, and both are searchable by the GPS-enabled wireless devices because their geographic coordinates were entered into a geocoded database which is continually updated. In addition, other information, such as the quality of the coffee shops or the price of gas, can also be integrated into the map and text information displayed to the user.

The law enforcement community has taken less advantage of GIS/GPS technologies than might be anticipated. A small but growing number of law enforcement agencies are deploying Automated Vehicle Location (AVL) systems, using GPS to track the location of patrol units and assist in navigation. Law enforcement agencies, however, have not yet routinely integrated their GIS data with AVL/GPS for use in their field operations. This lack of integration fails to take advantage of the myriad potential benefits of such systems, such as being able to identify nearby points of interest like the address an individual with a recently-issued arrest warrant. The ability to instantaneously visualize such information is expected to benefit police by allowing them to efficiently serve warrants, monitor parolees, and recognize crime patterns.

Smartphones and tablet computers are built with GPS/LBS capacities (and laptops also have, or can be fitted to have, LBS capacities), and it is a matter of time before, and creativity to define how, all these components will be used for police applications. Many police departments maintain current databases with the addresses of offenders. Some of them have been linked with crime and incident data using a GIS platform (Levine, 2006; Smartphones and Law Enforcement, 2011). Thus, the integration with LBS should be easily achievable, as all the components are already available (i.e., wireless data, the Internet, GIS criminal data, the mobile mapping application, and the GPS embedded in the phone or tablet).

The key question is how best to adapt LBS technologies to law enforcement? To make sure GIS crime outcomes (e.g., hotspot analysis, risk terrain modeling, crime prediction) are reliable, the actual location of a person of interest needs to be accurate. In order for police officers to efficiently use LBS technology, underlying geocoded information must be accurate and up-to-date (Roongpiboonsopit & Karimi, 2010). Often, this information is represented as geospatial point-data (i.e., pushpins) that depicts the last known location of persons of interest, or "POIs" (e.g., sex offenders, gang members, parolees, people with arrest warrants, broadcasts, persons with traffic citations, etc.). With LBS technology, those point features can not only reveal the geographic location of person of interest, but can also be embedded with web hyperlinks and anchor texts that allow officers to retrieve additional information from an internal reporting system of a police station. This adds the ability to display incident reports and other related information about the individual under investigation including mug shots and street-level photos of the location and its surroundings. Police officers can also request information about crimes that occurred near the target location and add different layers of information such as premise history and known hazards in the neighborhood, among other inputs (Casady, 2011a, 2011b). Police officers may also have the opportunity to write contact reports for individuals and instantly update the records management system without the need to physically be at the police station.

Studies have shown that contextual information provided in real time to police officers help them make better decisions while working in the field, such as acquiring additional information from an individual who has committed a traffic violation but has criminal records for dealing drugs, or avoiding traffic congestion that otherwise may have prevented an officer's timely arrival to an incident (Hu, Hidders, de Lignie, & Cimiano, 2011). Some of the advantages in using LBS technology in law enforcement are that geographic coordinates of contacts made by officers about POIs can automatically be stored in a centralized database allowing geo-statistical analysis to better predict the appearance of crime (Boondao & Tripathi, 2007). Additionally, the mapping display and searching tools (i.e., by specific address and name of POI) can be activated by a voice command which frees up the normal multitasking activities that an officer performs during patrolling activities increasing his or her situational awareness and safety, along with improving tactical decision-making process (Mancero, Wong, & Loomes, 2009).

A barrier for effectively utilizing any new technology is lack of interest or ability of the potential user. Social scientists have been studying the circumstances under which individuals adopt new technologies. Many of the most widely-used models of technology acceptance have focused on users' perceptions of the characteristics of technologies (Davis, 1989; Davis, Bagozzi, & Warshaw, 1989; Venkatesh & Davis, 2000; Venkatesh, Morris, Davis, & Davis, 2003). Some models have also included social-cognitive measures capturing the impact of user perceptions of what other individuals believe should be done, and of the availability of technical assistance. These models have largely been successful in explaining a high proportion of the variance in intended usage, but have been less successful in predicting sustained usage (Venkatesh et al., 2003): In employment situations, individuals must balance decisions to accept technology with issues far beyond their perceptions of the technology's usefulness and ease of use, and even beyond what influential individuals may believe should be done.

Cell phones, and more recently smartphones, appear to be adopted much like other technologies. Rogers (1995) noted, "Cellular phones have an almost ideal set of perceived attributes, and this is undoubtedly one reason for the innovation's very rapid rate of adoption in the U.S." (p. 245). Cell phones, observed Rogers, offer the attributes of *relative advantage* (saving time, status symbol, low cost) and *lack of complexity* (no sophisticated new skills necessary to use). Roberts and Pick (2004) identified cell phone acceptance to be a function of technological factors such as security, reliability, and web connectivity. A non-technological factor relevant for acceptance of cell technology is having robust customer service. Other factors such as cost, digital standards and technology product suitability have not been found to be as important. Overall, technological factors are more important than non-technological in terms of cell-phone, technology acceptance. Lu, Yu, Liu, and Yao (2003) found individual differences, technology complexity, facilitating conditions, social influences, and wireless trust environment determined user-perceived short and long term usefulness and ease of using wireless mobile devices to access the internet. The quality of mobile services and the fit of the application to the user's need can also influence utilization (Bouwman, Bejar, & Nikou, 2012; Bouwman, Haaker, & de Vos, 2008).

Technology adoption can have both its upsides and downsides (Colvin & Goh, 2005; Hampton & Langham, 2005; Nunn & Quinet, 2002). Colvin and Goh, for example, found the adoption of new devices by police officers in their daily operations, such as the use of Mobile Display Terminals (MDTs), resulted in increases of efficiency including reduced time spent on writing reports, increased access to crime information in databases, and increasing the police presence in the city (see also Ioimo & Aronson, 2004). However, MDTs also had negative impacts on officers, such as reducing social interactions (Colvin & Goh).

The Lincoln, Nebraska, LBS, Law Enforcement Application Project

Location-based technology (LBS) has the potential to radically reform law enforcement practices (Casady, 2011a, 2011b). However, will it be adopted by police officers? What social scientific model best explains the adoption of LBS technology? And if it used, will the LBS technology be used effectively?

We started by developing an LBS application for use by law enforcement officers. The LBS application we developed was for use on smartphones, tablets, and laptops. The LBS application uses geocoded police data and incorporates these data into the moving map of an AVL system so police officers are constantly being presented with information about events or persons relevant to their current position. After successful development and implementation, we evaluated officers' use of the application and technology and its impact. We wanted to assess not only whether there were policing benefits that accrued from introducing smartphones, tablets, and LBS technology to the Lincoln Police Department, we also wanted to assess the economic benefits versus the costs of using the technologies. In our police-impact evaluation, we looked at typical officer productivity measures: citation arrests, warrant arrests, and information reports. While we also collected miles driven data, under the assumption that officers would drive less because they would stop their cars and engage residents and others, asking about POIs and engaging in community-based policing, but we found that miles driven was not a productive variable for us and will not further discuss these data. (We did find a statistically significant difference: Treatment officers drove, on average, more per month, 1021 miles, than control officers, 904 miles, a statistically significant difference, but we were unable to ascertain a meaningful explanation for the difference.) Finally, we also examined what social scientific "uptake" model(s) best explains whether officers use the LBS technology.

Thus, our LBS development and evaluation project had three goals:

1) Develop the LBS technology for use by officers in the Lincoln Police Department;

2) Evaluate the LBS technology by assessing changes in relevant outcomes; and

3) Determine the best social science explanation for LBS technology adoption.

Goal #1: Creating the LBS Application

Our first task was to create a location-based application for use by officers in the Lincoln Police Department (LPD) on their smartphones, tablets, and car-based laptops. The application, which we called Proactive Police Patrol Information (P3i), is a mobile application for law enforcement officers to show on a computer screen persons-of-interest (POI), based on their residence and other location information contained in LPD's data base. The application uses location-based services to "push" information to officers in the field, showing POI locations on Google or Bing maps. Data that are pushed to officers using P3i include the home addresses of broadcasts, suspected gang members, parolees, registered sex offenders, arrest warrants, and the location of recent police-incidents. Officers can tap on a point (which is an address) to view details of the individuals there who have one or more of the interest attributes. Linked to the LPD's records management systems, the officers also can bring up a full history for POIs from the device. In addition to pushing data to the officers, P3i allows officers to enter contact reports for individuals that are submitted back to the department's record systems.

The P3i system is composed of two major components, a central data server and a mobile software application. The P3i server is responsible for collecting the various datasets that make up the entire POI database. It was built using cloud computing technologies and provides data to devices using REST web services. Data are stored in a relational database with a GIS extension to allow for spatial queries at runtime. The server also maintains security protocols for mobile devices, storing registration information for devices that may contact the server for data. Devices that are not registered are not able to access any of the server data set. In addition to providing management functionality, the server also includes a web-based version of the P3i mobile software. The web version of the software allows the application to run on standard Windows laptops that have a GPS unit attached. Middleware developed by the project team allows the GPS unit to communicate with the application. Data for P3i is geocoded from the police department records management system, using the same processes the department has used for over a decade in its internal GIS mapping applications. Data are refreshed daily, in both the department's database and the P3i server.

The client software is designed to provide a mobile "view" of the P3i server data set (Figures 2 & 3). Maps are presented on smartphones and tablets (GPS integrated) or an aftermarket GPS-unit integrated into car-based, laptop computers. The GPS also tracks the device's and user's location. Points of interest from the server are plotted on a map, centered on the user's current location. The mobile applications link to the server to provide individual record access as well as a secure link to agency record management systems, mug shot databases, and reporting facilities. The device also regularly reports its location to the server to achieve a level of AVL functionality and provides officer positions from the server plotted on the map alongside points of interest. The application also provides officers with Google map features such as aerial imagery, navigation, and StreetView images. Oblique aerial photography from Bing Maps also is incorporated into the application.

Figure 2. *Actual screenshot from P3i*
(as would be viewed by officer on each of the devices)

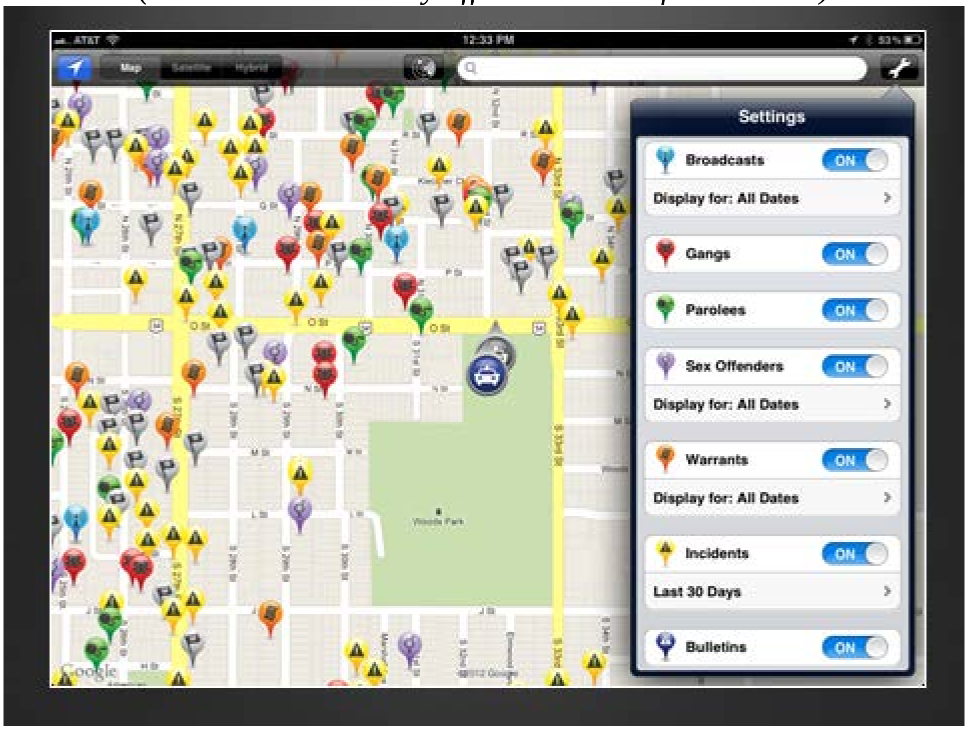
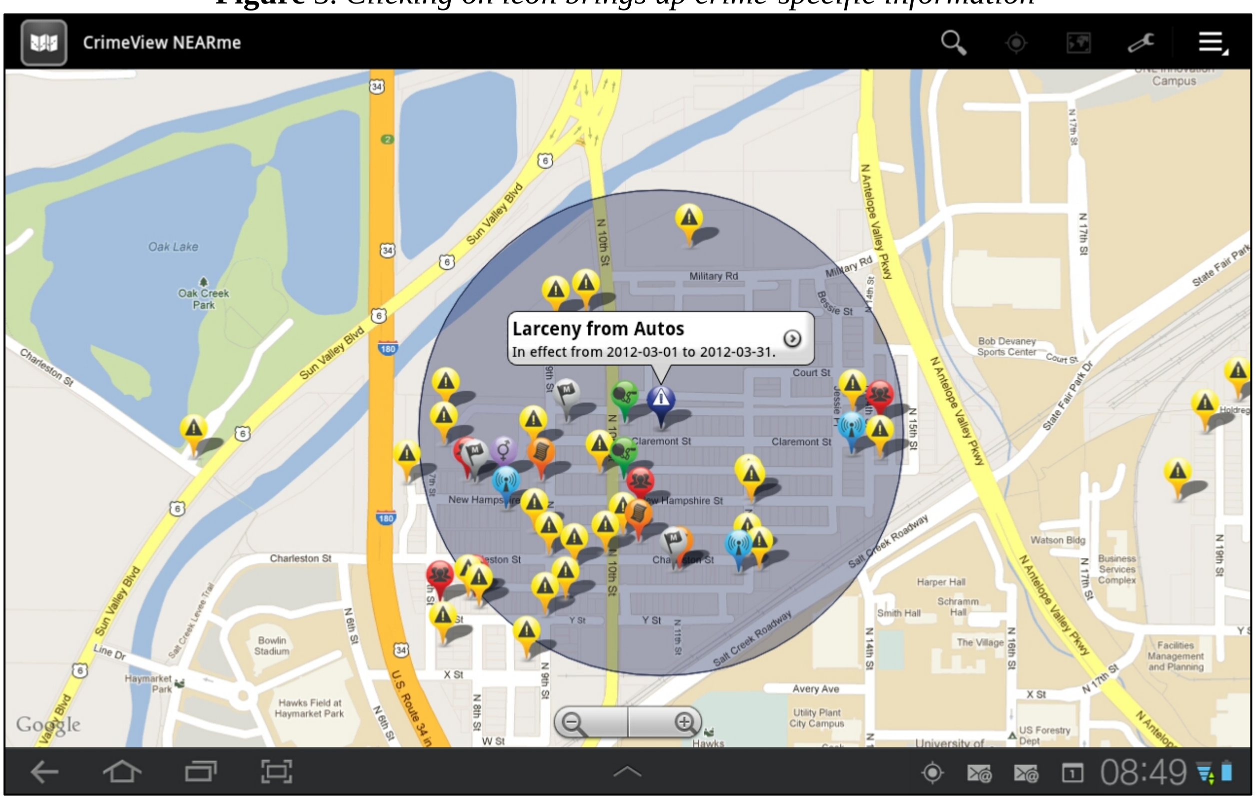


Figure 3. *Clicking on icon brings up crime-specific information*



Goal #2: Evaluation of the LBS Technology: An Experimental Field Trial

We examined six groups to assess LBS technology in the form of our P3i application, as deployed on five different devices (laptop; smartphone, Apple versus Android; and tablet, Apple versus Android). Thus, the six groups were:

1. Control Group: P3i not made available to officers
2. MDT/Laptop Treatment Group: Officers using mobile laptops with geospatial devices installed with P3i
3. iPhone Treatment Group: Officers using the iPhone installed with P3i
4. iPad Treatment Group: Officers using the iPad tablet installed with P3i
5. Android Treatment Group: Officers using a Motorola smartphone installed with P3i
6. Android Tablet Treatment Group: Officers using the Xoom tablet installed with P3i

Participants

All patrol officers in the Lincoln (Nebraska) Police Department (N = 263) were eligible to participate. Ninety officers were randomly selected, using a random number generator to select from a list of all LPD patrol officers, and invited to participate in the project. Informed consent forms were approved by the University of Nebraska-Lincoln’s Internal Review Board (IRB# 20110111327 EP) and given to participants.

We assigned the 90 Lincoln Police Department (LPD) officers to one of six groups:

- Group 1. A control group of officers was identified who would not use the P3i technology in any form, but their work outcomes would be monitored.
- Group 2. Fifteen officers assigned to use P3i via car-based laptops, specifically Mobile Data Terminals (MDT) equipped with aftermarket, GPS hardware. Their work outcomes would be examined, and they would be

invited to respond to surveys and participate in focus groups with the researchers.

- Groups 3-6. Sixty officers randomly assigned to use one of two phones (Apple or Android) *or* one of two tablets (Apple and Android). Given the proliferation of portable devices, we wanted to determine if Apple or Android products and if tablets or smartphones were preferred. These 60 officers would have their work outcomes examined, and they would be invited to respond to surveys and participate in focus groups with the researchers.

Treatment officers (Groups 2-6) were assigned to 1 of 18 training dates between May 3 and July 24, 2011. In these trainings, the officers were taught, if needed, how to operate their device, and they were all taught how to use the P3i application. Trainings were primarily conducted by Lincoln Police Chief Casady, a member of the research team.

The random sample of 90 officers was primarily male (87%), with an average age of 34.4 years (*SD* = 7.81, range = 22 to 58). There were no differences in officers' rank. Two officers from the Android cell phone group withdrew from the study within a few weeks of deployment, and they were replaced by two more randomly selected officers. This represented such a small percentage of the sample that no further assessment was made other than our recognition, bolstered by qualitative data obtained by the researchers, that the Android cell phone did not operate as seamlessly and effectively as desired, especially at first.

Random Assignment Check

We tested potential pre-existing differences among the groups using three variables collected by LPD via its Report Management System (RMS) during 2010. (Note: We were not able to obtain information on 3 of the 90 officers.) Specifically, we used warrant arrests, citation arrests, and information reports from the period of July 1 to December 31, 2010 (see Table 1). *Warrant arrests* are those pursuant to an arrest warrant. *Citation arrests* do not involve a warrant and are usually the result of the officer actually witnessing criminal activity. *Information reports* are non-arrest reports written by officers to create an official information record for the department and are filed at the discretion of the officer. Lincoln Police Department officials believe that information reports are most indicative of police officer productivity and accomplishment: It is via the informational report that officers can best share information with one another, making it more likely to lead to arrests versus the luck it takes to stop criminal behavior while it is taking place or the luck it takes to encounter and then arrest a suspect. Although officers are encouraged to submit at least one information report per month, the filing of information reports is dependent on the officer's initiative.

Table 1 – 2010 Outcome Variable Univariate Statistics

Name	Description	*n*	Min	Max	Mean	*SD*
2010 RMS Warrant Arrests	Arrest pursuant to an arrest warrant	87	0	29	7.41	5.74
2010 RMS Citation Arrests	No arrest warrant	86	1	270	50.92	52.15
2010 RMS Information Reports	Non-arrest information reports	86	0	69	10.30	9.55

RMS: LPD Record Management System
Numbers of police officers do not equal 90 because those with missing data are omitted

There was no omnibus effect of device on warrant arrests ($F(5,86) = 1.32$, $p = .27$), 2010 citation arrests ($F(5,85) = 0.53$, $p = .76$), or information reports ($F(5,85) = 1.47$, $p = .21$). Follow-up LSD tests, however, revealed two significant comparisons: Officers who were randomly assigned to the control group had filed significantly less reports than Android Smartphone (Mean Difference = 7.58, $p = .04$) or Xoom Tablet users (Mean Difference = 8.27, $p = .02$) before the system was implemented. No other follow-up comparisons were significant. Thus, we feel confident there were no systematic pre-existing differences among the officers as they were assigned to groups that would impact our evaluation of the use of the technology.

Two tests were conducted to identify potential cohort effects related to the device training date. To test for a systematic change over time, a variable was computed that represented the project date on which training occurred for non-control participants (i.e., a value of one would indicate that the officer's training occurred one day after the first training date, May 3, 2011). Correlations were computed between this variable and 2010 warrant arrests ($r(72) = -.05$, $p = .65$), 2010 citation arrests ($r(71) = -.08$, $p = .54$), and 2010 information reports ($r(71) = -.03$, $p = .83$), and were all non-significant. We also created a variable to compare officers on the basis of the month in which they were trained (May, June, or July). Again, the omnibus tests for 2010 warrant arrests ($F(2,71) = 0.21$, $p = .81$), 2010 citation arrests ($F(2,70) = 0.37$, $p = .70$), and 2010 information reports ($F(2,70) = 0.25$, $p = .78$) were non-significant. Follow-up LSD tests comparing months individually were also non-significant. Thus, there is clear evidence to show officers did not have pre-existing differences related to their training date.

Measures

Each officer was followed and relevant police data (arrests and information reports) collected for six months subsequent to his/her training on the use of P3i (evaluation period). As is shown in Table 2, we examined three categories of law enforcement outcomes – *citation arrests, warrant arrests, and information reports* – during this six month period. In addition, comparisons were made between 2010 and 2011 the arrests and information reports (see Table 1).

During the same six month period, we also collected technology adoption data in the form of surveys that obtained *self-reports* from the officers about their use of the electronic devices and P3i. Officers assigned the mobile devices loaded with the P3i application were asked to report the duration, frequency, and intensity of their use of the technology on 1-5 scales (labeled from (1) strongly disagree to (5) strongly agree), one month (Time 1) and six months (Time 2) after their training date. The items revealed good internal consistency at both time points (α_{T1} = .86; α_{T2} = .87) and so were averaged to create a single score for the two time points (T1 and T2, reported in Table 2). We will discuss these data related to technology uptake, below, as part of Goal #3, *determining the best social science model for explaining location-based technology adoption*.

Table 2 – 2011 and Survey Outcome Variable Univariate Statistics

Name	Description	*n*	Min.	Max.	Mean	SD
2011 RMS Warrant Arrests	Arrest pursuant to an arrest warrant	88	0	33	8.88	6.03
2011 RMS Citation Arrests	No arrest warrant	88	6	238	46.93	41.18
2011 RMS Information Reports	Non-arrest information reports	88	0	53	11.68	9.40
2011 P3i Information Reports	Selected reports filed via P3i	90	0	29	3.11	5.21
2011 Total Information Reports	2011 RMS and P3i information reports	88	0	56	14.84	11.32
T1 DFI	Mean of self-reported duration, frequency, and intensity of system use at *one* month	75	1.00	5.00	3.00	0.89
T2 DFI	Mean of self-reported duration, frequency, and intensity of system use at *six* months	63	1.00	4.67	2.67	0.98

RMS: LPD Record Management System
DFI: Duration, Frequency, Intensity of Technology Use
Numbers of police officers do not equal 90 in four of the first five rows because those with missing data are omitted
Twelve officers in the treatment conditions completed surveys at T1 but not at T2

Quantitative Results: Law Enforcement Outcomes

The bivariate correlations among the outcome variables are reported in Table 3. The correlations reveal statistically significant relationships between warrant arrests and citation arrests, warrant arrests and information reports using the P3i technology (but not warrant arrests and traditional information reports), citation arrests and traditional information reports (but not

P3i information reports), citation arrests and Time 1 self-report usage of the technology (but not Time 2), P3i information reports and self-reports of technology use at Times 1 & 2, and Time 1 and Time 2 self-reports of usage. Thus, our outcome measures were fairly correlated (almost half the possible correlations were significant).

Table 3 – Outcome Variable Correlations

	1	2	3	4	5
1 - 2011 RMS Warrant Arrests					
2 - 2011 RMS Citations Arrests	0.48*				
3 - 2011 RMS Information Reports	0.20	0.23*			
4 - 2011 P3i Information Reports	0.26*	-0.05	0.12		
5 - T1 DFI	0.04	-0.27*	-0.09	0.39*	
6 - T2 DFI	-0.03	-0.23	0.14	0.36*	0.65*

** $p < .05$.*
RMS: LPD Record Management System
DFI: Self-Report of Officer Duration, Frequency, and Intensity of Technology Use

We evaluated three productivity measures collected by LPD's record management system (RMS). We examined the number of citation arrests, warrant arrests, and information reports for officers. Because information reports were deemed the best measure of officer productivity (as discussed above), this outcome especially was of interest for the evaluation.

There were significant differences between officers in the control group and the five treatment groups related to citation arrests and warrant arrests. On average, officers in the treatment groups had more citation arrests per month (8.24) than officers in the control group (6.80), a statistically significant difference at the 90% confidence level, and officers in the treatment groups had more warrant arrests per month (1.57) than officers in the control group (1.22), a statistically significant difference at the 96% confidence level. There were not statistically significant differences across devices.

For information reports, the data reveal more treatment officers had more information reports per month (2.09) than control officers (1.39), a statistically significant difference at the 99% confidence level. In total, as shown in Table 4, treatment officers filed more total information reports on average (M = 16.18; SD = 11.52) than controls (M = 8.33; SD = 7.73; $F(1, 87) = 6.34$, p = .01). We compared each of the experimental groups to the control officers. The omnibus F-test was non-significant ($F(5,87) = 1.57$, p = .18), but follow-up LSD analyses revealed significant differences for most experimental groups versus control. Droid, iPad, and Xoom users filed significantly more total information reports than control (Table 4; recall, though, that control officers filed significantly less reports than Droid or Xoom users at the start of the study, before the implementation of P3i). iPhone users were only marginally higher and MDT/laptop users were not statistically different from the control officers; however, both groups filed considerably more reports numerically. For iPhone users, the large mean difference ($M_1 - M_2 = 8.00$, p =.053) and large effect size (d = 0.73) suggests that the lack of significance is likely the result of an insufficient sample rather than a lack of a meaningful difference. For laptop users, the case is less clear-cut as the effect size in particular, though sizeable, is notably smaller (d = 0.51).

Table 4 –Group Comparisons on Information Reports Filed in 2011

Group	*n*	Mean	*SD*	Sig. vs. Control	Comparison Effect Size
Control	15	8.33	7.73	-	
All Treatment Conditions	73	16.18*	11.52	p = .01	
Droid Smartphone	14	17.57*	12.00	p = .03	d = 0.92
iPad Tablet	14	16.64*	7.86	p < .05	d = 1.07
iPhone	15	16.33	13.53	p = .05	d = 0.73
MDT (Laptop)	15	13.00	10.27	p = .26	d = 0.51
Xoom Tablet	15	17.47*	13.71	p = .03	d = 0.82

Asterisked means are significantly different from Control Officer Group (p < .05).

Comparisons, 2010 versus 2011

Although treatment groups had more warrant and citation arrests in 2011 than the control group, there were no differences compared to 2010. We tested for differences in productivity from 2010 to 2011 using information reports. In 2010, information reports were exclusively submitted via the RMS system, but in 2011 officers had the additional portal of submitting via the P3i system. It was therefore necessary to compute a new variable for total 2011 information reports by adding the 2011 RMS and 2011 P3i information reports. Because the RMS system was the only information report portal available in 2010, we simply used the 2010 RMS Information Reports variable for 2010.

A paired samples *t*-test comparing 2011 reports to 2010 for the five treatment groups revealed a significant mean difference such that on average in 2011 (after the implementation of P3i), *officers filed more reports* ($t(70) = 3.90$, $p < .001$). In order to better understand any potential differences across officers, we re-tested the mean differences specifically for high and low performers (identified using a mean split of information reports at 2010 or 2011), gender (male or female), young or old (identified using a mean split of age), and relatively new or old officers (identified using a mean split of years of service; see Table 5). As shown in Table 5, the mean difference remained significant (with a higher value for 2011) for officers below the mean of performance in 2010, above the mean of performance in 2011, males, both younger and older officers, and officers below the mean number of years of service. However, high performers in 2011, low performers in 2010, and officers above the mean of years of service did not significantly change across time suggesting no effect of P3i for these individuals. Note that female officers also did not experience a significant increase over time; however, the small sample of women ($n = 10$) complicates the interpretation of this finding. It is possible that the lack of statistical significance is more a result of a lack of statistical power than a true lack of an effect, but note also that the mean difference is negative, indicating that female officer performance was, on average, worse after the implementation of the system (albeit non-significantly so).

Table 5 – Change in Information Reports from 2010-2011 by Officer Characteristics

Name	M of original scale variable	# in each group	2010-2011 t-test	2011-2010 Mean Difference
High and Low Performers in 2010	11.68	below = 55	$t(54) = 5.58$, $p < .001$	6.27*
		above = 31	$t(30) = 0.84$, $p = .41$	2.13
High and Low Performers in 2011	14.84	below = 49	$t(46) = -0.17$, $p = .92$	-0.09
		above = 39	$t(38) = 5.15$, $p < .001$	10.64*
Gender	-	female = 10	$t(9) = -0.66$, $p = .52$	-3.30
		male = 65	$t(60) = 5.22$, $p < .001$	6.66*
Age	34.49	below = 43	$t(40) = 2.12$, $p = .04$	3.93*
		above = 32	$t(29) = 3.66$, $p = .001$	7.07*
Years of Service	8.23	below = 44	$t(42) = 4.11$, $p < .001$	6.16*
		above = 31	$t(27) = 1.52$, $p = .14$	3.86

Asterisked mean differences are significantly different over time (p < .05).

Although these findings suggest the efficacy of the system for most officers (particularly in light of the fact that crime in Lincoln decreased from 2010 to 2011), they do not necessarily mean that the system was the mechanism for the increase (e.g., the officers most responsible for an increase in productivity may have been those who used the system least). In order to shed some light on this question, we computed a change score for information reports such that positive scores indicate increases in information reports over time and negative scores indicate decreases over time. We then correlated this change score with self-reported system usage (DFI) at T1 (one month after training) and T2 (six months after training). T1 DFI was significantly related to change in information reports, $r(75) = .25$, $p = .03$, while T2 DFI was not, $r(63) = .20$, $p = .11$. Importantly however, the small sample size and moderate effect size ($r = .20$) suggest that the lack of significance at T2 may be a result of sample size. Even so, the effect was smaller than at T1 ($r = .25$), suggesting that officer's early report of their system usage was most related to changes in productivity.

Qualitative Methods and Results

Focus groups were conducted with members of the five treatment groups to assess how police officers were using the devices, their level of satisfaction, any technical issues they may have encountered during the operation of the application, and the kinds of law enforcement decisions that were made based on the information provided by P3i. Two rounds of focus groups were conducted, first near the beginning of the deployment of P3i (*n* = 24) and after six-months of P3i usage (*n* = 14). In addition, follow-up, individual interviews with two participants were conducted in June 2012.

Focus Groups

Two research specialists from the University of Nebraska Public Policy Center conducted the focus groups with police officers. Contacts with police officers willing to participate in the focus groups were made through internal channels at the Lincoln Police Department, that is, the officers were contacted by the senior members of the department (Chief, Assistant Chief, other supervisors). Officers were informed participation in the focus groups was voluntary. Dates for the focus groups were scheduled according to police officer's availability. Participants in the focus groups received informed consent forms that they were asked to read and sign, and they were also verbally informed of the purpose of the discussion and informed again of it being a voluntary activity. There were no drop-outs.

Those who attended the focus groups were asked to answer semi-structured, probe questions (see the Appendix for the instrument):

1) How is P3i used in your daily operations?

2) Can you describe the benefits of P3i?

3) Can you describe the negative aspects of P3i?

4) Do you have any suggestions to improve P3i?

5) Do you feel more motivated at work because of the use of the software?

6) Have you noticed any impacts in your social lives because of the use of P3i?

7) Have you noticed any changes in miles driven since starting using P3i?

8) Would you recommend this software to others?

Research specialists allowed police officers to openly discuss any aspects of the software and how it operated with different devices. Notes were taken during the focus groups, and then qualitatively analyzed grouping them into similar topics. The following topics were raised by the officers: 1) Mode of operation; 2) Technical issues; 3) Efficiencies and effectiveness; 4) Impact on social interactions and 'big-brother' effect; 5) Changes in motivation; 6) Practical applications and benefits; 7) Operational recommendations; and 8) Technical recommendations.

As reflected in the perspectives from the officers who participated in the focus groups, those who chose to participate in the focus groups were very positive and enthusiastic about P3i, and offered some valuable insights. Because the participants in the focus groups may have been those officers more satisfied with the mobile devices and the P3i application, the results of our focus groups do not necessarily reflect the views of all (n = 75) the Lincoln officers who were assigned devices loaded with the P3i application.

Mode of operation. Most of police officers mentioned that they use the software before patrolling their geographic area. Some police officers indicated they would start their shift by driving to a parking lot, and then retrieving P3i data. When needed, officers might pull over to check for some specific POIs, or they may recognize people's faces on the streets that they would like to get more information on, using the software. For instance, several police officers mentioned they could focus better on particular POIs, such as sex offenders. One police officer stated, "I will go where the clusters of bubbles are."

Police officers valued the fact that they can “tailor” the software according to their own needs, filtering out specific POIs based on their police beat, feeling more autonomous and independent in their work. The officers mentioned they feel goal-oriented by having specific targets to deal with on their daily operations. Some police officers will go to “problem areas,” and see what is new in the system.

One police officer mentioned feeling “like you are now driving with a purpose.” Another police officer mentioned prioritizing according to the type of POI that was displayed on the device: “Like being able to prioritize the warrants (…) can pick up the domestic violence guy over the guy with the speeding ticket warrant.” Another police officer added: “Knowing how long warrants have been active is helpful.”

Most police officers used P3i to search for both broadcasts and warrants, and most of them indicated that they use P3i during their downtime (i.e., between calls). In the opinion of the LPD Police Chief, “The users tend to take a time block on a day with low service demand, and work comparatively intensively.” He added: “You'll see an officer logging in hot-and-heavy for a while, and then disappear for weeks.” (Casady, personal communication).

Phone users (iPhone and Droid) indicated they usually carry their devices with them when leaving their patrol car (i.e., using their shirt-pockets). In contrast, the tablet users indicated they preferred leaving their devices in their patrol car since they felt that it was not safe to move around with such a big device in their hands. Regardless of the device used, a police officer opined, “no officer should ever be bored with P3i available to them.”

Technical issues. Overall, police officers found that learning to operate the software was very simple. One police officer mentioned that “these devices simplify what existed before – no clicks on a computer required – it’s just in your face and auto-updates.”

Other police officers valued the fact that the application was simple to operate without feeling overwhelmed by the information provided by P3i: "[I am] not overwhelmed by information. Knowing the info is available is great. Knowing it is not screaming at you is great." This contrasts with the experience of officers in the Netherlands (Streefkerk et al., 2008), where there were complaints concerning a similar-type of application that sounded alarms, vibrated, and displayed dynamic graphics when in proximity of a POI. These effects made police officers feel overwhelmed by the amount of visual and sound effects which had a counterproductive impact on use and acceptance (Streefkerk et al.).

Police officers liked the graphic aspects of the P3i software, especially the "bubbles" showing POIs. Having software that could give them an overall idea of the criminal situation of the city, not just tabular data, but adding the geographic dimension of it, was highly valued. One police officer observed, "You know that all of these people and situations are out there, but you don't think about it until you see all the bubbles… or you don't think it's your problem because it was someone else's case." Many officers mentioned having a visual display of POIs helped them to get a better idea of criminal activities in the city.

The Lincoln police officers quickly realized that turning P3i application on all the time drains the batteries quite fast. Consequently, they turned on the application only when necessary to increase battery life. As one officer mentioned, "iPad has great battery life if you just put it to sleep when not in use."

A limitation of P3i that came out during focus groups was that Android phone users indicated that they often encountered technical difficulties in getting P3i to operate on their devices. It is our belief that the older version of Android (2.3), and the processing power of the hardware (Motorola Droid2), were less than ideal for this application. **(**Individual interviews with two Droid phone users elicited more details and are reported below.)

iPad users liked the size of the screen since allowed police officers to be more comfortable in filling out reports. It is "[n]ice having the iPad when doing reports because of the bigger screen size," reported one officer. The opposite was mentioned by an iPhone user: "iPhone screen is too tiny to go back and forth between RMS and P3i." In general, tablet users liked the screen size of their devices, in comparison to the smart-phone users who mentioned more limitations when interacting with P3i due to smaller screen sizes.

Efficiencies and effectiveness. Police officers felt that using the software made them more productive as they have access to current information for their daily operations. One police officer mentioned: "Almost forces you to be proactive when you're driving around …." Others said: "When you have that much information at your fingertips it is very easy to be proactive in your downtime," and, "With all the information you have, you feel more like you are not wasting your time." Another police officer added how fast the access to information is done using P3i in comparison to the traditional MDT/laptop: "[P3i offers] quicker access to information. Sometimes using an MDT can take 3-5 minutes, and info coming over the radio can be hard to hear." An officer added, I "[w]ould love to have this [P3i] in MDT's, or [on their own] personal devices."

Police officers mentioned that they preplan their daily activities using the software so they can make better decisions on how to use their time more efficiently and more effectively. In the opinion of one police officer, pre-planning using the software also increases safety: "You know whether or not you should be thinking about calling for backup before you go in." P3i has been useful when patrolling areas of the city at night, especially in new or isolated urban areas, providing extra protection to police officers. Also, when police officers visit an apartment complex, they can retrieve information from many households at once, providing useful information of what or who else is there, therefore increasing their feeling of being safe.

In general, the Lincoln police officers liked being able to use the maps, especially in the case of a suspect who was running away because they could see on the map where to go and how to make the best plan for arriving help. One police officer mentioned "really lik[ing] the 'sex offender' option. It's a real time saver when it comes to following up on them."

Efficiencies identified by the officers were related to the fact that police officers do not necessarily need to go back to their substations to retrieve information from POIs, print documents, and then go back to their original location. By collecting data through P3i, and then connecting that data with the RMS, trips to the substations decreased as police officers access information directly from the RMS.

One police officer mentioned that this used to take "double time" in comparison to the current situation using the software, and it now requires "less effort" to retrieve key information about warrants/broadcasts and associated mug shots of POIs. Another police officer mentioned clearing "up two broadcasts in one day. One from [a year earlier]."

There was a question about whether P3i increased driving efficiency. In the opinion of one participant, "there is no noticeable difference in the amount of driving, maybe just more efficient driving." Another officer added: "May not see the mileage cut down – but you will see a better use of mileage." For one police officer the use of P3i may actually have a negative effect on driving: "There may a bit less driving because the work is generated from and can be done from the cruiser." Other police officers also shared the same opinion about the no-effect in miles driving due to the use of the software.

Impact on social interactions and the potential "big-brother" effect. Colvin and Goh (2005) reported that when MDTs were installed in patrol cruisers, it adversely affected officers' social lives, since they had less time to share with their peers at the substations. During the focus groups, the question was posed about whether the use of the technology negatively impacted the officers' relationships with fellow officers. The Lincoln officers responded the use of P3i has not affected their social lives with other peers or their interacting at substations. One police officer responded not missing anything social due to technology: "You are still going to see your teammates and folks at the substation. The fact they may need to stop by less doesn't feel like they are missing anything." Another police officer added: "Now that you have Internet and tools in your car… you are not telling stories in the substation anyway."

Some police officers considered whether the "big-brother" effect of having a device that could track their geographic positions 24/7. While potentially troublesome, the benefits of having the software with them outweighed potential negative effects. One police officer observed, "The big brother aspect is a little intimidating, but knowing where everyone is and who is out there – makes it a bit safer, especially in a situation where you could not get to your radio. If you get knocked out, folks will know where you are." Another police officer mentioned that "if they [management] start using it for discipline, officers are just going to flat out not to use it."

Changes in motivation. Police officers were asked if they felt more motivated doing their regular work because of the use of the software. All police officers in the focus groups mentioned that the software did not make them more motivated; rather they mentioned the software, along with their other devices they carry, was another useful tool for their daily activities. One officer mentioned it was "satisfying to know that you are closing cases," but the motivation level was the same, observed the officer.

Practical applications and benefits. Officers mentioned P3i has been useful when cases of sexual assault or indecent exposure have occurred in the city, as they could retrieve information of known sex offenders located nearby. This process expedited the search and recognition of suspects by the victims.

In the field, police officers have been able to identify persons of interests without IDs by looking up addresses in P3i and displaying their mug shots. This has resulted in arrests that otherwise would have not occurred without the assistance of P3i. Police officers valued this feature of the software as it frees up other time for tasks that he/she can now do and not waste radio time, etc. In the words of one police officer, “It’s nice when verifying photos of those with warrants to real life.”

One police officer mentioned how much the use of P3i has affected the job: “I would say that contact with people has gone up by maybe 50% …. [I] try to make a couple of contacts on warrants each day.” By increasing the number of contacts with POIs, it has also impacted law enforcement outcomes, with one police officer indicating making “five arrests in about one hour on one shift in particular!” Another police officer added: “Knocked on about 10 doors in a week. It’s hard to just drive by when you know it’s right there.” One police officer mentioned people are at awe when they reference information back to them: “People are generally floored by how much officers know about them from the jump.” One POI blamed the device for being caught, said an officer!

There have been a number of practical applications that have benefited police officers on their daily operations. The following briefly describes specific situations where the devices alone, or coupled with the software, have been useful in law enforcement activities or have changed internal operations:

1. P3i has benefited the update of bad addresses as patrol officers can submit correct locations to the RMS. One police officer reported: "I have found a few address glitches – North and South get mixed up sometimes." Another added: "That [bad address feature] is working really well. Within 24 hours the addresses are changed. And that helps everyone."
2. The provisioning of a mobile device increased police officers' ability to make a contact with a POI through a restricted phone number.
3. A victim of an assault was able to pinpoint where he was and could say "I was there," without transporting him out of the hospital.
4. Through the use of P3i, Channel 50 (radio communication between police station and officer) is, according to several officers, "used less and less." An officer reported, "Folks who work at Channel 50 have noticed a drop in activity on their end of requests, especially at night." Police officers are mostly using Channel 50 to confirm warrants and double check with information provided by P3i.
5. There is advantage to filling out reports using P3i without the need of a "report room," which is the case in hospitals, for example.

Operational recommendations. Many police officers indicated that it would be more efficient if P3i was available on multiple devices when patrolling. They would prefer a tablet or an MDT when they are in the patrol car, but use another device (e.g., smartphone) when they leave the car. Other police officers mentioned that having an iPad acting as an MDT would be beneficial: "If iPad had a keyboard and you used that as MDT, that would be great." Another officer added: "If the tablet was in a bracket in your cruiser instead of MDT and you had the phone for portability – that would be awesome. Plus, if you could mount the tablet, it would be less distracting than setting it in the passenger seat."

Police officers were asked if they would recommend P3i to others. All police officers made positive comments about the application: "Yes, absolutely. Feel more informed. It gives personal satisfaction." Another was equally enthusiastic: "I would recommend this [P3i] to another officer – no questions asked." Some police officers mentioned it would also depend on the internal policies and kind of information that a police department has: "Not all departments give their officers as much information as we do. LPD is really advanced." Another added: "It depends on internal policies and existing info." Most police officers commented they would like to keep their devices after the research ends.

Officers feel that having two policemen per cruiser may create more efficiencies and increase their safety. The rationale is that one police officer can focus on driving the cruiser, and the copilot will have full operational capabilities using the software, gathering as much tactical information as possible before arriving at their location. Police officers believe that doing this may decrease accidents while driving, while also increasing safety in the field as police officers can better focus on their surroundings, which may result in an increased awareness of potential threats (i.e., where to park by considering the safest location). Police officers think that direct outcomes of having two police officers per cruiser may increase productivity, as more contacts with persons of interest and resultant reports should be expected.

Technical recommendations. Several officers mentioned that they would like to add the latest date and number of contact attempts with POIs that have been made above the graphic pins ("bubbles"), so they could decide whether or not a new contact attempt should be conducted. Police officers also mentioned that symbols (i.e., pins depicting different kind of POIs) were not very effective since they were difficult to differentiate by size or color. Some of their comments were: “I hate the icons;” “Symbols are worthless. Colors are important to differentiate;” “[I d]on’t remember what the symbol is;” “Make it simple;” and, “Smaller icons” are needed. Other complaints were related to the graphic depiction of the patrol car on the app which did not change in size when changing scale and has the tendency to overlap other symbols.

Other police officers suggested that changes are needed to the “Filing Report” feature. Problems included it lacking a “back” button to make changes, or allowing one to quit and start from the beginning without “having to go through all of the questions to get out of there.”

Police officers made recommendations that could assist in extending the battery life of devices. One police officer discovered that “if you turn off apps and leave “Safari” running to refresh the homepage you can go about a week without charging the battery on the iPhone.” Another police officer mentioned that “if you put the apps to sleep you can go about two shifts without charging the Xoom.”

Interviews

The focus groups revealed that Droid phone users were the least satisfied and showed the lowest usage among all treatment groups. In order to identify the causes of these outcomes, individual interviews were conducted with two Droid phone users. The interviews were conducted by a research specialist with the University of Nebraska Public Policy Center. Interviews were semi-structured, asking about their overall opinion about the software.

One police officer indicated that the reason for his dissatisfaction was that the software was unresponsive (“kicking off of the system”) and unstable (it was crashing all the time). Therefore, he decided to drop out of the study. He mentioned he knew the software was very useful for patrolling activities, and he understood the benefits of having his device with P3i, but he got too frustrated turning it on and off on several occasions to make it work.

A second police officer also mentioned the technical difficulties in operating P3i with a Droid phone. He mentioned, however, that this impediment did not prevent him in using the application all the time. This police officer was extremely satisfied with the direct benefits offered by P3i in his daily activities, and he felt that its benefits outweighed its limitations.

Cost-Benefit Analysis

As discussed above, the treatment groups experienced an increase in productivity overall as a benefit of the treatment. It is possible to estimate the value of this increase in productivity. The basic idea is that if the treatment makes officers more productive, then fewer officer hours would be needed to make the same number of arrests as were made before the treatment. This results in a cost saving. For example, if 100 arrests were made before the treatment (i.e., use of technology), and the treatment allows 110 arrests to be made, fewer officer hours would be needed to make 100 arrests with the treatment. The saved time could mean any choice or combination of the following: a reduction in overall payrolls; an ability to get more types of other policing done with no extra cost; or changes in the composition of the police workforce (i.e., hiring junior police officers to replace senior police officers). If the extra policing is valued at the cost of officer hours, the cost saving is a measure of the benefit from the treatment by making police officers more productive. Table 6 outlines the measurement of that benefit. Row 1 of Table 6 shows that officers in the control group averaged 1.2 warrant arrests per month. If each arrest takes an average 1.25 hours per officer, then assuming 173 working hours per month,[1] row 3 of Table 6 shows that officers in the control group spend approximately one percent of their time per month on warrant arrests.[2]

Table 6 - Benefits from Technology "Treatment"

		Warrant Arrests
[1]	Control Arrests/Month	1.2
[2]	Hours/Arrest (From LPD)	1.25
[3]	% of Month Time in Warrant Arrests ([1]*[2]/173)	1%
[4]	Control Group	-0.1
[5]	Treatment Group	0.31
[6]	Difference between Treatment and Control ([5]-[4])	0.41
[7]	Part of Warrant Arrest Time Saved ([6]/[1])	34%
[8]	Part of Officer Saved ({1-[7]}*[3])	0.3%
[9]	Annual Cost/Officer (From LPD)	$64,571
[10]	Monthly Cost/Officer ([9]/12)	$5,381
[11]	Monthly Savings/Officer ([10]*[8])	$16
[12]	Years/Device	5
[13]	Discount Rate	7%
[14]	Present Discounted Value (PDV) Savings/Officer	$801

Row 4 of Table 6 shows that officers in the control group had a reduction of 0.1 warrant arrests per month between 2010 and 2011. Row 5 of Table 6 shows that officers in the aggregate of treatment groups had an increase of 0.31 warrant arrests per month. Comparing the control group to the aggregate of treatment groups implies an increase of 0.41 warrant arrests due to the treatment. Row 7 of Table 6 shows that because of the treatment, 34 percent fewer officer hours previously spent by the treatment group making warrant arrests would be needed to make as many warrant arrests as the control group. Row 8 of Table 6 shows that a 34 percent reduction in the 1% of an officer's time spent on warrant arrests would result in a 0.3 percent savings in time per month for the control officers.

[1] 173 working hours per month is 21.7 days per month times eight hours per day.
[2] The 1.25 hours per arrest estimate was obtained from the Lincoln Police Department.

At an annual cost of $64,571 per officer, or a monthly cost of $5,381, a 0.3 percent reduction in time results in a monthly saving of $16 per treatment officer as shown in row 11 of Table 6. If a device lasts five years and future savings are discounted at a 7% interest rate, the present discounted value of savings due to the treatment is about $800 per treatment officer as shown in row 14 of Table 6. In police departments with thousands of police officers in their workforce, total savings can be substantial, especially when considering budgetary constraints, without jeopardizing public safety by keeping a more proactive and effective workforce in the field. It is also important to consider that the P3i technology can be installed in most devices that police officers already have for their personal use; therefore, it is expected that indirect saving costs for police departments may be even greater.

Alternative scenarios

Table 7 shows results under alternative scenarios. Row [1] allows a useful life of either three or five years. The second row shows the present discounted value (PDV) of benefits per office over the relevant useful life. These values are generated using the procedure described in Table 6, above. Line [3] shows a cost per device. The $500 cost is for an iPad. The $200 amount represents the average cost of smartphones and tablets. Row [4] of Table 7 allows for a usage cost. That cost is either zero or $10. The latter amount was used as it reflects likely discounts from multiple devices contracted for by the police department. Row [5] shows the present discounted value of usage costs over the life of the device. Total costs – device costs [3] plus usage costs [5] – are shown in row [6]. Finally, row [7] shows the present discounted value of the net benefit (row [2] minus row [6]). The net benefit ranges from a positive $601 to a negative $310 depending on the cost of the device, monthly usage charges and the life of the device.

Table 7 - Net Benefit under Alternative Assumptions

[1]	Years/Device	5	5	3	3	5	5	3	3
[2]	PDV Savings/Officer	$801	$801	$514	$514	$801	$801	$514	$514
[3]	Cost/Device	$500	$500	$500	$500	$200	$200	$200	$200
[4]	Monthly Usage Cost	$0	$10	$0	$10	$0	$10	$0	$10
[5]	PDV Usage/Device	$0	$505	$0	$324	$0	$505	$0	$324
[6]	PDV Total Cost	$500	$1,005	$500	$824	$200	$705	$200	$524
[7]	PDV Net Benefit	$301	($204)	$14	($310)	$601	$96	$314	($10)

The original cost of the device has a significant impact in the resultant present discounted value (PDV) net benefits. Thus, PDV net benefits are $300 lower for iPads ($500 cost) when compared with an average device ($200 cost). Usage costs can also have a significant impact on the present discounted value of the net benefit. Finally useful life matters in that it allows a longer time to generate benefits from the initial costs. Cumulatively, the results show that iPads only have positive net benefits when there are no usage costs, while other devices have positive net benefits in almost all cases.

Goal #3: Determine the Best Social Science Model for Explaining LBS Technology Adoption

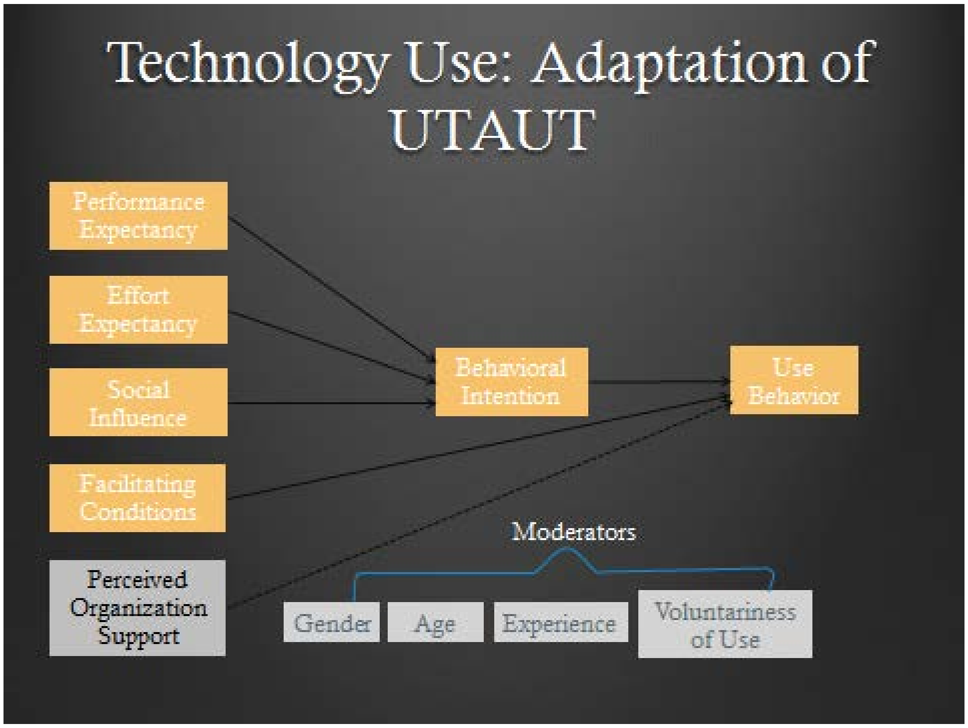
New technological devices are not always adopted by individuals or organizations. The introduction of innovative technologies may fail, not because of technological impairments, but rather because users simply prefer to not adopt them (Pool, 1997; Rogers, 1995). In the last 20 years, behavioral research has been conducted to establish those factors that make a device likely to be rejected or adopted by users. This is particularly relevant for this project as new geospatial devices are being incorporated into the daily activities of police officers.

Our inquiry is somewhat unique in the United States. In law enforcement contexts, there have been numerous studies examining what predicts technology adoption in other countries (e.g., Al-Zaabi, Choudrie, & Lebcir, 2012; Allen & Wilson, 2005; Bouwman et al., 2008; Bouwman & Van de Wijngaert, 2009; Bouwman, Van de Wijngaert, & de Vos, 2008; Chen, Du,

& Zhang, 2009; Collerette, Legris, & Manghi, 2006; Colvin & Goh, 2005; Dal Fiore & Beinat, 2008; Ellahi & Manarvi, 2010; Hu, Chen, Hu, Larson, & Butierez, 2011; Hu, Lin, & Chen, 2005; Kadir, 2013; Kurkinen, 2012, 2013; Lin, Hu, & Chen, 2004; Lindsay, Jackson, & Cooke, 2013; Odabasi, 2010; Pica & Sørensen, 2004; Singh & Hackney, 2011; Sørensen & Pica, 2005; Srisarkun, 2004; Straus, Bikson, Balkovich, & Pane, 2010; Yalcinkaya, 2007), but not very many in the U.S. One U.S. program of research (Arizona: Hu et al., 2011; Hu et al., 2005; Lin et al., 2004) is particularly relevant to the research reported here: Our study is somewhat similar to the most recent study published by the Arizona team (Hu et al., 2011), both in approach (moving beyond behavioral intentions to include relevant outcomes: see generally, Ajzen, & Fishbein, 1980) and in findings.

The Unified Theory of Technology Acceptance and Use (UTAUT) model posits four constructs that predict intention to use information systems (Venkatesh et *al*., 2003) (see Figure 4, first four constructs in the first column). The four constructs are: 1) performance expectancy (i.e., "the degree to which the user expects that using the system will help him or her attain gains in job performance," p. 447); 2) effort expectancy (i.e., "the degree of ease associated with the use of the system," p. 450); 3) social influence (i.e., "the degree to which an individual perceives that important others believe that he or she should use the new system," p. 451), and 4) facilitating conditions (i.e., "degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system," p. 453). The items used by Venkatesh and Davis have explained up to 60% of the variance in usage intentions, and incorporate constructs found in other technology acceptance models. Of all the constructs, however, performance expectancy (also called "perceived usefulness" in the widely-researched Technology Acceptance Model) typically has been the leading predictor of intention to use technology (Davis, 1989; Davis, Bagozzi, & Warshaw, 1989; Lederer, Maupin, Sena, and Zhuang, 2000), including use of smartphones (Park & Chen, 2007).

Figure 4. *Technology Use Model*



In employment situations, individuals must balance decisions to accept technology with issues far beyond their perceptions of the technology's usefulness and ease of use, and even beyond what influential individuals may believe should be done. According to organizational research, an employee engages in a relationship with the employing organization that is distinct from those with peers, supervisors, or senior managers (Wayne, Shore, & Liden, 1997). An employee's perception about the organization is the sum of global beliefs about the extent to which the employee believes the organization values their contribution, cares for their well-being, and will reward their efforts toward meeting organizational goals (Eisenberger, Armeli, Rexwinkel, Lynch, & Rhoades, 2001; Eisenberger, Huntington, Hutchison, & Sowa, 1986). Increased employee perceived organizational support (POS) has been related to increases in felt obligation to reciprocate through increased in-role and extra-role behaviors (Eisenberger et al., 1986; Settoon, Bennett, & Liden, 1996; Shore & Tetrick, 1991).

The role of the organizational-employee relationship has received little attention in the technology acceptance literatures. Organizations adopt technology to achieve a variety of worthwhile purposes such as creating value, improving competitiveness, enhancing client relationships, and increasing productivity (Boone & Ganeshan, 2001; Dewan, Jing, & Seidmann, 2000; Ives & Learmonth, 1984; Luftman & Ben-Zvi, 2010; Mahmood & Soon, 1991; Tallon & Kraemer, 2007). Employees use proffered technologies to achieve the desired organizational gains, yet there are multiple studies of employees resisting new technologies (Bhattacherjee & Hikmet, 2007; Jiang, Muhanna, & Klein, 2000; Lapointe & Rivard, 2005; Timmons, 2003). Past technology acceptance theories have not explored how felt obligation on the part of employees to the organization may impact technology usage in the workplace. None of the technology acceptance theories included in UTAUT incorporates notions of *organizational support*, in terms of employee-employer (organization) social exchange relationship (Eisenberger et al., 2001; Lee, Kozar, & Larsen, 2003; Lee, Hsieh, & Ma, 2011). Thus, our research not only examined UTAUT constructs in the law enforcement context, we also examined the potential contribution of perceived organizational support for P3i technology adoption (Figure 4, fifth construct in the first column).

Methods

As discussed previously, self-reports of technology adoption were collected from the 75 officers who were assigned a mobile device that had P3i operating on it. An online (Qualtrics) survey was administered one month after first use of the mobile device and technology and then again at six months after an officer’s first use. The survey contained questions that allowed us to test the UTAUT and the Perceived Organizational Support frameworks. Items from UTAUT (Venkatesh et *al*., 2003) and the Survey of Perceived Organizational Support (SPOS) were included. Both the original SPOS and subsequent shortened versions have exhibited high internal reliability and uni-dimensionality in a variety of occupations and settings, including policing (Armeli, Eisenberger, Fasolo, & Lynch, 1998; Lynch, Eisenberger, & Armeli, 1999; Shore & Tetrick, 1991; Shore & Wayne, 1993). Nine questions were selected using two criteria for the selection: 1) questions must have the highest loaded values SPOS (Eisenberger et al., 2001; Eisenberger, Cummings, Armeli, & Lynch, 1997; Eisenberger, Fasolo, & Davis-LaMastro, 1990; Eisenberger et al., 1986; Hutchison, 1997; Lynch et al., 1999; Rhoades, Eisenberger, & Armeli, 2001; Shore & Wayne, 1993), and 2) be representative of the evaluative judgments considered in the survey, such as employee's performance, consideration of the employee's goals and opinions, the employee's satisfaction on the job, and employee's wellbeing. Finally, we also self-report information from the officers relevant to their adoption of the technologies. As we reported above:

> Officers assigned the mobile devices loaded with the P3i application were asked to report the duration, frequency, and intensity of their use of the technology on 1-5 scales (labeled from (1) strongly disagree to (5) strongly agree), one month (Time 1) and six months (Time 2) after their training date. The items revealed good internal consistency at both time points (α_{T1} = .86; α_{T2} = .87) and so were averaged to create a single score for the two time points (T1 and T2, reported in Table 2).

We also assessed differences across the five systems (laptop + Apple/Android types of cell phones + Apple/Android types of tablets).

A draft survey first was piloted with three police officers who were not among the 90 officers participating in the P3i evaluation project. These officers first tested the P3i application for one week and then were asked to review the survey. We asked them for feedback on content, readability, and length of the survey. We were encouraged to change a few key words in order to facilitate better understanding of the items by participants (e.g., it was suggested that we change "senior management" to "supervisor," which we did).

We had a 100% response rate to the survey at T1 (75/75) and an 84% response rate at T2 (63/75). Analyses of systematic differences of the 12 drop-outs did not reveal anything noteworthy.

Results

We first examined the UTAUT and Duration, Frequency and Intensity of Usage (DFI) construct scales at both Time 1 and Time 2. Because our focus was on a model test, we evaluated the constructs in a complete model at each time point. Following the traditionally applied methodologies from technology acceptance literatures, we utilized a partial least squares approach via SmartPLS (Ringle, Wende, & Will, 2005). PLS differs from more standard approaches to model estimation primarily through its use of the covariance in the responses. Additionally, unlike more common approaches (e.g., CFA), PLS does not compare a data covariance matrix to the matrix expected from the relationships identified and so lacks model fit statistics but does provide the model parameter estimates needed to evaluate the UTAUT constructs and model. The initial model (M1) for Time 1 included all items with loadings on their hypothesized factors and DFI regressed on the predictor variables. As shown in Table 8, all duration, frequency, and intensity; performance expectancy (PE); effort expectancy (EE); and perceived organizational support (POS) items loaded highly on their hypothesized factors (> .7) at Time 1. Social influence (SI) and facilitating conditions (FC), however, had items with low loadings. We therefore eliminated the low-loading items and re-estimated the model (M2). Note that FC2@T1 had a low loading in model M1 but was kept in model M2 where it loaded at the .7 cutoff. Time 2 was much the same as Time 1 with many of the same low loaders in the initial Time 2 model (M3). A second Time 2 model (M4) was therefore estimated with the low loaders, again, removed.

Table 8 – PLS Factor Model Loadings

Construct		Item	T1 Loading		T2 Loading	
			M1	M2	M3	M4
Duration, Frequency, Intensity (DFI)	1.	I use P3i daily in my work.	.89	.89	.86	.90
	2.	I use P3i all the time in my work.	.90	.90	.93	.93
	3.	I extensively rely on P3i for my work.	.85	.85	.88	.88
Performance Expectancy (PE)	1.	I find P3i useful in my job.	.83	.83	.89	.89
	2.	Using P3i enables me to accomplish tasks more quickly.	.83	.83	.90	.90
	3.	Using P3i increases my productivity.	.81	.81	.91	.91
Effort Expectancy (EE)	1.	My interaction with P3i is clear and understandable.	.86	.86	.89	.89
	2.	It is easy for me to become skillful at using P3i.	.90	.90	.87	.87
	3.	I find P3i easy to use.	.89	.89	.90	.90
	4.	Learning to operate P3i is easy for me.	.80	.80	.77	.77
Social Influence (SI)	1.	People who influence my behavior at work think that I should use P3i.	*.62*	-	.94	.95
	2.	People who are important to me at work think that I should use P3i.	.90	.90	.88	.92
	3.	My supervisors have been helpful in the use of P3i.	.72	.76	.82	.81
	4.	In general, Lincoln Police Department has supported the use of P3i	*.57*	-	*.44*	-
Facilitating Conditions (FC)	1.	I have the resources necessary to use P3i.	.91	.96	.72	.71
	2.	I have the knowledge necessary to use P3i.	.66	.70	.78	.86
	3.	RECODED - P3i is not compatible with other systems I use.	*.40*	-	*.34*	-
	4.	A specific person (or group) is available for assistance with system difficulties.	*.15*	-	*.68*	-
Perceived Organizational Support (POS)	1.	Lincoln Police Department strongly considers my goals and values	.87	.87	.86	.86
	2.	Help is available from Lincoln Police Department when I have a problem.	.85	.85	.71	.71
	3.	Lincoln Police Department really cares about my well-being.	.82	.82	.92	.92
	4.	RECODED - Even if I did the best job possible, Lincoln Police Department would fail to notice.	.72	.72	.71	.71
	5.	Lincoln Police Department cares about my general satisfaction at work.	.91	.91	.80	.80
	6.	RECODED - Lincoln Police Department shows very little concern for me.	.74	.74	.80	.80
	7.	Lincoln Police Department cares about my opinions.	.85	.85	.86	.86
	8.	Lincoln Police Department takes pride in my accomplishments at work.	.88	.88	.83	.83
	9.	Lincoln Police Department is willing to extend itself in order to help me perform my job to the best of my ability.	.83	.83	.86	.86

Likert scaled responses: 1= Strongly agree to 5 = Strongly disagree.
Note. "RECODED" *indicates items that were reverse coded before analysis.*

Having evaluated the items in PLS models, we next evaluated the scale items' reliability and the distributions and relationships among construct item averages. As reported in Table 9, the construct scales were largely normally distributed and, with a few exceptions, yielded good reliability as measured by Cronbach's Alpha ($\alpha > .7$). SI and FC at Time 1 were all low, but it is of note to recall that these were two to four item scales which often yield poor reliability. FC at Time 2, however, did yield a problematically low reliability estimate ($\alpha = .37$). Regarding the construct relationships, Tables 9-11 show the correlations among Time 1 constructs (Table 10), Time 2 constructs (Table 11), and between Time 1 and Time 2 constructs respectively (Table 12). Within Time 1, most constructs were significantly correlated with the exception of POS whose relationships with DFI and FC were all non-significant. Time 2 was similar with POS lacking significant relationships with most of the other variables (all except SI). FC was also not significantly correlated with SI. Over time, all Time 1 constructs were significantly correlated with their Time 2 counterparts and, as would be expected, these were consistently the strongest relationships.

Table 9 – Scale Means, Distributions, and Reliability

	Time 1						Time 2					
	N of Items	M	SD	Skew	Kurt.	α	N of Items	M	SD	Skew	Kurt.	α
DFI*	3	3.00	0.89	-0.25	-0.31	.86	3	2.67	0.98	0.09	-0.79	.87
PE*	3	3.84	0.68	-0.81	1.33	.75	3	3.58	0.86	-0.50	0.05	.88
EE	4	4.20	0.57	-0.53	0.99	.88	4	4.23	0.51	-0.53	1.79	.88
SI	2	3.20	0.76	0.10	0.80	.57	3	3.08	0.82	-0.22	0.40	.87
FC	2	4.22	0.53	-0.35	1.38	.62	2	4.23	0.522	-0.51	1.26	.37
POS*	9	3.22	0.84	-0.63	0.08	.95	9	3.05	0.82	-0.62	-0.04	.94

Note. Asterisked constructs are significantly different across time ($p < .05$). Italicized constructs were not comparable over time because the scales contain different items.
DFI: Duration, Frequency, Intensity
PE: Performance Expectancy
EE: Effort Expectancy
SI: Social Influence
FC: Facilitating Conditions
POS: Perceived Organizational Support

Table 10 – Time 1

	DFI@T1	PE@T1	EE@T1	SI@T1	FC@T1	POS@T1
DFI@T1	-					
PE@T1	0.69*	-				
EE@T1	0.39*	0.51*	-			
SI@T1	0.37*	0.46*	0.34*	-		
FC@T1	0.27*	0.44*	0.76*	0.33*	-	
POS@T1	0.08	0.27*	0.32*	0.32*	0.20	-

* *p < .05*.

Table 11 – Time 2

	DFI@T2	PE@T2	EE@T2	SI@T2	FC@T2	POS@T2
DFI@T2	-					
PE@T2	0.77*	-				
EE@T2	0.46*	0.47*	-			
SI@T2	0.64*	0.69*	0.29*	-		
FC@T2	0.32*	0.37*	0.71*	0.22	-	
POS@T2	0.23	0.21	0.17	0.44*	0.18	-

* *p < .05*.

Table 12 – Time 1-Time 2

	DFI@T1	PE@T1	EE@T1	SI@T1	FC@T1	POS@T1
DFI@T2	**0.65***	0.47*	0.36*	0.47*	0.20	0.26*
PE@T2	0.50*	**0.52***	0.50*	0.45*	0.31*	0.28*
EE@T2	0.36*	0.38*	**0.75***	0.33*	0.59*	0.26*
SI@T2	0.40*	0.43*	0.25*	**0.62***	0.18	0.47*
FC@T2	0.15	0.29*	0.49*	0.22	**0.52***	0.21
POS@T2	-0.04	0.09	0.01	0.35*	0.03	**0.80***

* *p < .05*.

Bolded cells are construct correlations over time.

Model Testing

Having identified the bivariate relationships among item averages of the constructs, we next estimated a structural regression model using SmartPLS in which DFI was regressed on PE, EE, SI, FC, and POS and total information reports filed in 2011 was regressed on DFI. Significance was determined via bootstrapping with 200 samples and mean replacement for missing variables. At Time 1, the only significant predictor of DFI was PE which was a strong and positive independent predictor (see Table 13). DFI did not have a significant relationship with total information reports filed in 2011. Time 2 contained similar relationships except that SI was a significant predictor and DFI's relationship with total information reports filed became significant (Table 14).

Table 13 – Time 1 Structural Regression

Construct	Role	R^2	Regression Coefficient	Bootstrapping *t*-value
Performance Expectancy	Predictor	-	0.66	6.44*
Effort Expectancy	Predictor	-	0.16	0.92
Social Influence	Predictor	-	0.10	1.16
Facilitating Conditions	Predictor	-	-0.12	0.79
Perceived Organizational Support	Predictor	-	-0.14	0.99
Duration, Frequency, Intensity	Criterion/ Predictor	.50	0.10	1.25
Total Information Reports in 2011	Criterion	.01	-	-

Note. Asterisked t-values are significant (t-value > 1.96).

Table 14 – Time 2 Structural Regression

Construct	Role	R^2	Regression Coefficient	Bootstrapping *t*-value
Performance Expectancy	Predictor	-	0.55	5.38*
Effort Expectancy	Predictor	-	0.17	1.66
Social Influence	Predictor	-	0.29	1.97*
Facilitating Conditions	Predictor	-	-0.04	0.32
Perceived Organizational Support	Predictor	-	0.03	0.36
Duration, Frequency, Intensity	Criterion/ Predictor	.64	0.24	2.27*
Total Information Reports in 2011	Criterion	.06	-	-

Note. Asterisked t-values are significant (t-value > 1.96).

The UTAUT model enabled us to test constructs that related to police officer acceptance and use of P3i. UTAUT was extended in two unique ways. First, the actual usage of the technology was included as a dependent variable, as measured by number of information reports. Many previous studies of UTAUT and of related technology adoption models, rely only on self-reported use, but do not measure the relationship between self-reported use and measurable outcomes of use. In this study, we added information reports as a measurable outcome of use of P3i. Second, the construct capturing perceived organizational support was added to UTAUT as in independent predictor of self-reported use of P3i. We expected, since P3i was in some ways an extra-role activity, officers that perceived higher organizational support would be more likely to engage in using it.

As expected, performance expectancy was a significant predictor of self-report use. Similar to other studies, including use of smartphones (Park & Chen, 2007) individuals adopt technology they believe will help improve their performance. Positive for P3i is that at T2, officers' belief that the technology would improve their performance increased, as did their self-reported use. It is interesting to note that social influence joined performance expectancy as a predictor of use in T2. In other studies of UTAUT, social influence may have independent significance at the initial introduction of a technology (particularly for women), but its influence typically rapidly fades. In this study, social influence was not a predictor in T1, but rose to predictive status 6 months following the implementation.

In testing the relationship between self-reported use and actual use (as measured by information reports), we found a non-significant relationship of T1 self-reported use to the following years' use. However, the T2 self-reported use was related to actual use. One explanation for this result could be that information reports were not a good proxy for actual use. That is, information reports did not fully capture actual use of the system, or that officers needed time to adapt to the application in order to later use it to file information reports. Other actual measures of use, such as the number of hours the application was activated or some other measure were not available, but could have been superior proxies for use.

Because we expected that POS was a new concept to the UTAUT model, we did not hypothesize correlations between it and the other independent constructs. However, we thought there might be a correlation between POS and SI given the possibility that officers might conflate "important persons" with the police department as an entity. As expected, POS was uncorrelated with the other independent constructs (excepting SI in T1). We expected a significant correlation between POS and self-reported use and actual use, but found these neither at T1 nor T2. Further, the POS had no significant independent effect on use (self-report or actual). Contrary to our expectations, officers' relationships to the police department as an entity did not play a role in their decision to use P3i.

Discussion

To summarize, a primary objective of this study was a proof of concept to determine whether we could develop an-easy-to-use GPS application for law enforcement officers that would operate on commercially-available and widely-used, hand-held computing devices (Apple and Android smartphones and tablets). The GPS application would integrate geocoded police data into moving maps on an AVL system so that police officers could constantly access information about events or persons relevant to their current position. Along with a similar project in Redlands, California (e.g., Albright, 2012; Taniguchi, 2012), our efforts showed that this can be done and that police officers can and will make use of the technology.

After considering a variety of measures, such as citation arrests, warrant arrests, and information reports, we decided the most relevant outcome measures to use would be information reports and warrant arrests. We concluded that information reports are the kind of outcomes sensitive to the use of the technology, and we used warrant arrests so that we could make a benefit-cost assessment.

Our results showed information reports submitted by Lincoln police officers were significantly, albeit not much in terms of actual numbers, impacted by using P3i. Follow-up analyses suggested a variety of individual difference factors (e.g., high performance officers in 2011, low performance officers in 2010, males) were related to productivity increases.

We also determined, using LPD warrant arrest data, that the benefits outweighed the costs of purchasing and using the necessary software and hardware. Although the precise benefit varied according to the assumptions made and values used, except for more expensive equipment (iPads), the benefits consistently outweighed the costs. Future cost benefit analysis should include social costs involved by having a more productive police workforce, and how having safer communities may also have administrative and infrastructure costs for police departments and cities at large.

As indicated, the quantitative results provided evidence of some increased productivity for officers using the P3i mobile application. The use of P3i was driven by officers' expectations of how well the technology would assist them in their work. Thus, our study supports the position that if technology is made available, and officers have a reasonable expectation that it will help them in their work, they will utilize the technology. Further, if that technology actually can help them in their efforts, it is likely that the increase in productivity can be measured and captured. Our project also shows, however, that it may be difficult to find sensitive measures that will capture increases in productivity. One problem that can be anticipated is that outcomes are multi-determined, and thus it can be difficult to find measures that will be sensitive to positive impacts because of the multiple causes for the effects in which we are interested. Also, the small treatment sample size may have impacted the power of some of our results and therefore the strength of our findings (e.g., gender effects; differences in performance at T1 vs. T2). Despite this limitation, this project advances our understanding of technology acceptance in policing, suggesting the same factors that are important in other workplace settings also are applicable in law enforcement.

The qualitative data provide another avenue of understanding possible impacts. In our study, officers participating in the two focus groups were almost universally enthusiastic about the technology. Officers confirmed liking to use the technology, and that enthusiasm was not dampened even by the early problems with P3i on Android devices.

The evaluation of P3i, bolstered by using random assignment to conditions, thus demonstrated that a location-based service for displaying points of interest applicable to police officers in the field could be created, linked to the extant, police-records, management system, and successfully deployed to field personnel relatively quickly and with reasonable costs by using methods and tools already in wide use in other applications and disciplines. The project showed police officers could be trained to use location-based services and such devices with relative ease, and further showed officers can incorporate such tools into their work effectively, although the uptake of this technology varied.

During the period of this study, smartphones and tablet underwent explosive growth in the general population. The proliferation of these devices undoubtedly will impact policing as well. This study demonstrated that police-specific applications can be deployed to leverage the convergence of mobile devices and GPS capability to the benefit of law enforcement. The processing power of mobile devices increased dramatically during this time period, as well as the bandwidth available on mobile networks. These developments no doubt will make this technology even more useful to law enforcement, increasing efficiencies and effectiveness as power and speed continue to proliferate.

In the long-term, then, we can anticipate that mobile technology will be utilized by law enforcement. What explains uptake in the short-term, before technology is widely adopted? Our study reinforced the findings from other workplace studies, showing that performance expectancy, a belief that the device will aid in the performance of duties, has the primary significant effect on self-reported adoption and use (see also Hu et al., 2011; Park & Chen, 2007). We can anticipate a role for social factors as well (Lindsay et al., 2013). When technology does not operate ideally, however, officers will be frustrated and adoption will be slower as was the case when a similar type of technology was introduced in the Netherlands, sending officers an overwhelming number of alerts and signals when approaching POIs and information that was not relevant (Streefkerk et al., 2008).

Our findings have policy impacts for the criminal justice system: The increasing availability of geospatial data can result in system efficiencies at minimal extra costs or even produce cost-savings. Communities will be better served as the law-enforcement communities utilize location-oriented technologies. Many police departments already maintain databases with addresses of offenders, key locations of gangs and sex offenders, and so on. The integration with location-based services is easily achievable, as all the components are already available (i.e., wireless data, the Internet, GIS criminal data, the mobile mapping application, and GPS embedded in phones and tablets).

As we found related to providing information reports, although it may be slow to take root, over time we believe the bundling with other applications of the kind of technology we developed for this project will be valuable. Officers will want to access a suite of relevant software products within a single portal that will enable them to easily and quickly access information residing on secure-servers in the police station, and, in return, the officer in the field can instantaneously send back critical information, in real-time, to the server and to fellow officers in the field as well as in the central office. One feature developed for P3i after the study allows officers to see the location of other officers, a feature about which officers were very enthusiastic (see also Straus et al., 2010).

Future research of apps like P3i should also consider whether having two officers per patrol car may impact productivity and safety. Other research should address how the availability of greater spatial information (e.g., geographic extension and richness) provided to police officers can affect changes in police workforce tactics. When analyzing cost/benefits for the introduction of a new device for a police department, such as P3i, not only should direct costs be included, but also the social and policing costs and benefits associated with it should be investigated, such as crime-rate reduction and increased sense of safety for both officers and the public. Moreover, with the development of new body-attached mobile devices, such as Google glass, opens up the opportunity to continue testing applications like P3i for other opportunities in police patrolling. It is expected that, regardless of the type of device, the design aspects of the software along with the active participation of police officers and managers (e.g., Chiefs of Police) at different stages of development (e.g., pre-design, development, pre-test, deployment, evaluation, and post-evaluation) will continue to be crucial in making sure that it will receive a high acceptance by end users.

Finally, there is a question of whether researchers are best positioned to continue the next phases of development (e.g., dissemination of technology) that are required in order to make sure that applications are useful in a rapidly changing technology environment. We thought that as researchers, we were not well poised to take the next steps. However, we saw opportunity in commercialization. In response to considerable interest among law enforcement agencies in P3i, and pursuant to permission from NIJ, we undertook steps to make P3i commercially available. We recognized a university-led team of investigators, along with a public official (Lincoln's chief of police), were not ideally suited to assure widespread dissemination and ensure the necessary, ongoing updating to the software that would be essential if it were to be a product that would be more than a proof-of-concept and instead be usable in the field.

The project team worked with the technology transfer unit of the university, NUTech Ventures, http://www.nutechventures.org/, and licensed Red Brain Law Enforcement Services (a start-up company, led by project partner Ian Cottingham and joined by Tom Casady, Juan Paulo Ramírez, Ashok Samal, and Alan Tomkins), a subsidiary of Red Brain, Inc., a software-development firm headed by Cottingham (http://www.nutechventures.org/connect/innovators/ian-cottingham), to market P3i (http://research.unl.edu/stories/story.php?ID=1285). Red Brain entered into a partnership with the Omega Group (http://www.theomegagroup.com/), a national company that develops, markets and supports a wide-variety of law enforcement software tools, to distribute and market P3i as CrimeView NearMe (see, e.g., http://info.theomegagroup.com/introducing-the-industrys-first-proactive-policing-mobile-application/; http://en.wikipedia.org/wiki/CrimeView). The agreement, which became effective on December 23, 2011, allows Omega exclusive access to resell, market, and distributed P3i in accordance with the Software License Agreement between Red Brain Law Enforcement Services and NUTech Ventures. Red Brain Law Enforcement Services retains exclusive development rights under the agreement, which lasts for 4 years with an annual renewal each year thereafter. CrimeView NearMe is an Omega owned trademark and is being used to allow P3i to be recognized as an Omega application.

Our experience with Omega reveals that the *commercial* uptake of technology is yet another challenge. To date, Omega is not making extensive use of P3i/NearMe. That of course is their business prerogative, but it does reflect that simply creating a product is not enough. It is not an insurmountable challenge, but for us, even with the assistance of Red Brain as a commercial intermediary, we realize that we do not have the expertise or resources for the extensive marketing and/or client management that would be required to make sure products thrive in the marketplace.

In conclusion, this project does point out opportunities for the National Institute of Justice as it continues to promote technological innovations as one means to improve law enforcement outcomes. Although any research or business idea cannot be assured success, the possibility of simultaneously developing a crime-fighting application at the same time a social science model is tested (in this instance, technology adoption) allows NIJ to advance scientific knowledge and impact policing in one project, not a bad ROI.

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Other Dissemination Presentations

2013

- Nebraska GIS/LIS Consortium Conference, Kearney, NE

2012

- COPS Conference, Bethesda
- IACP Annual Conference, San Diego
- Mid-America GIS Consortium Conference, Kansas City
- Nebraska Chapter of APCO/NENA Conference, Omaha
- Omega Group Users Conference, San Diego

2011

- Nebraska Law Enforcement Technology Conference, Kearney, NE
- NIJ MAPS Conference, Miami

We've also conducted several web conferences to demonstrate the app, and/or face-to-face demos at site visits with police departments including (US) Des Moines; Duluth, MN; Las Vegas; Philadelphia; Rochester, MN; San Diego County Sheriff; and (Outside US) Abu Dhabi National Police.

P3i Application for Downloading (Public Version)

The application is free to download from the Apple (updated May 2014) and Droid app stores (updated May 2014):
https://itunes.apple.com/app/proactive-police-patrol-information/id453492069?mt=8
https://play.google.com/store/apps/details?id=com.redbrain.p3i&hl=en

Blogs

Tom Casady, The Director's Desk (blog, 4/15/13), Sounds Familiar,
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http://lpd304.blogspot.com/2011/06/location-based-services.html

Eugene Mueller, Omega's CrimeView® Dashboard and CrimeView Nearme Mobile Solutions Capture Attention at the 2012 International Association of Police Chiefs (IACP) Annual Conference, http://info.theomegagroup.com/blog/bid/162726/Omega-s-CrimeView-Dashboard-and-CrimeView-Nearme-Mobile-Solutions-Capture-Attention-at-the-2012-International-Association-of-Police-Chiefs-IACP-Annual-Conference

The Project Discussed in Online and Print Articles

- Law Enforcement/Justice
  - Jessica Mansourian, (2012, September). 2012 COPS Conference Recap: Need a Way to Increase Police Efficiency and Enhance Officer Safety with a Limited Budget? There's an App for That!, Community Policing Dispatch: E-Newsletter of the COPS Office, *5* (9), available online from http://cops.usdoj.gov/html/dispatch/09-2012/TechnologyandPolicing.asp
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- News Outlets and Blogs
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- University of Nebraska stories:
    - o http://www.nutechventures.org/connect/news/unl-spinout-deploys-mobile-software-nationwide
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    - o http://newsroom.unl.edu/announce/todayatunl/555/3294
    - o http://newsroom.unl.edu/announce/cse/620/3461

Other

The project was featured in Lincoln Police Department's 2011 Annual Report (p. 8, see below):

EXEMPLARY PROGRAM

P3i | CrimeView NEARme

On June 14, 2011, Proactive Police Patrol information (P3i) was publicly launched as a location-based services application. It was developed and deployed at the Lincoln Police Department in collaboration with the University of Nebraska and with funding from the National Institute of Justice.

During the fall of 2010, the University was awarded a grant to develop and study this technology. Public Safety Director Tom Casady was the co-principal investigator on this project. In the ensuing months, the application went through much iteration, as collaborators at the Department of Computer Science and Engineering continued to enhance and improve P3i. Deployment began on May 4, 2011 with P3i in the hands of 60 Lincoln Police officers, using the application on four different devices: iPhones, iPads, Motorola Xoom tablets, and Droid2 smart phones. Fifteen more were added later when a version of the application was loaded to mobile data computers (Panasonic Toughbooks) in the cruisers.

P3i works the same way many other location-based services apps. It's a map-based application that displays the "police points of interest" around you, based on your current coordinates. The map moves with you as you walk or drive, and the points simply stream towards you as the map scrolls. If you are using it on a smartphone, when you pull it out of your pocket, it's already centered on your location. The points of interest represent the locations of recent crimes, the addresses of parolees, registered sex offenders, people with arrest warrants and so forth. These data are updated daily. We use very similar data in our internal mapping applications, so the process was already in place to automatically gather and geocode these data from our reporting systems for display in a geographic framework. With P3i, we have moved these data to the street as a location-based service. Just as you might use Google Maps or Bing on a smartphone to search for a restaurant, then click the icon to bring up a photo, a link to its website, and a button to launch Streetview, you can do all the same things in P3i. Rather than the restaurant, though, it's the sex offender who lives in the corner house, or the guy in apartment 201 with an arrest warrant that you might not have known about without this technology.

UNL's Public Policy Center is in the process of conducting research to shed some light on how this technology impacts policing and police officers. In addition, the University of Nebraska's research commercialization program, NUtech Venutures, has helped the UNL developers form a marketing arrangement with the Omega Group, makers of CrimeView, a popular suite of GIS and crime analysis software products for law enforcement. In early 2012, the Omega Group rebranded P3i as CrimeView NEARme. Prior to this roll out, developers Ian Cottingham and Kevin Farrell added a few new features, including location-aware crime bulletins. In the coming years, we anticipate watching this application evolve, increasing the efficiency and effectiveness of our officers.

Using the technology also is part of the Lincoln Police Department's long-range strategic plan, see LPD, Strategic Plan (2012-2016, p. 7), available from www.lincoln.ne.gov/city/police/pdf/stratplan.pdf

Appendices

Appendix A: P3i Survey

Appendix B: Focus Group instrument

Appendix A: P3i Survey

Directions: Please read the following statements about P3i. Indicated how strongly you agree or disagree with each statement by clicking on the appropriate button[3].

		Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
PERFORMANCE EXPECTANCY						
1	I find P3i useful in my job.					
2	Using P3i enables me to accomplish tasks more quickly.					
3	Using P3i increases my productivity.					
EFFORT EXPECTANCY						
4	My interaction with P3i is clear and understandable.					
5	It is easy for me to become skillful at using P3i.					
6	I find P3i easy to use.					
7	Learning to operate P3i is easy for me.					
SOCIAL INFLUENCE						
8	People who influence my behavior at work think that I should use P3i.					
9	People who are important to me at work think that I should use P3i.					
10	My supervisors have been helpful in the use of P3i.					
11	In general, Lincoln Police Department has supported the use of P3i.					
FACILITATING CONDITIONS (FC)						
12	I have the resources necessary to use P3i.					
13	I have the knowledge necessary to use P3i.					
14	P3i is not compatible with other systems I use.					
15	A specific person (or group) is available for assistance with system difficulties.					
PERCEIVED ORGANIZATIONAL SUPPORT (POS)						
16	Lincoln Police Department strongly considers my goals and values.					
17	Help is available from Lincoln Police Department when I have a problem.					
18	Lincoln Police Department really cares about my well-being.					
19	Even if I did the best job possible, Lincoln Police Department would fail to notice.					
20	Lincoln Police Department cares about my general satisfaction at work.					
21	Lincoln Police Department shows very little concern for me.					
22	Lincoln Police Department cares about my opinions.					
23	Lincoln Police Department takes pride in my accomplishments at work.					
24	Lincoln Police Department is willing to extend itself in order to help me perform my job to the best of my ability.					
DURATION – FREQUENCY – INTENSITY (DFI)						
25	I use P3i daily in my work.					
26	I use P3i all the time in my work.					
27	I extensively rely on P3i for my work.					
SYSTEM QUALITY (SQ)						
28	The size of the device I am using works well for me while in the patrol car.					
29	This device works well for me when I leave the patrol car and in the field.					
30	I would like to have visual contact with P3i while driving.					
31	The size of the visual display makes P3i hard to work with.					
32	P3i is a distraction while driving.					
33	I am satisfied using P3i with my current device.					
34	It is easy to read system information on the device.					
35	It is easy to find the information I need in P3i.					

[3] This was administered as an online survey.

		Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
SYSTEM QUALITY (SQ) – Cont’						
36	It is easy to enter information into P3i.					
37	I am satisfied with the current device that I am using the P3i application on.					
DEVICE WORKS WELL (WW)						
38	From what I hear or know, the iPad works well with the P3i application.					
39	From what I hear or know, the iPhone works well with the P3i application.					
40	From what I hear or know, the Motorola Xoom tablet works well with the P3i application.					
41	From what I hear or know, the laptop works well with the P3i application.					
42	From what I hear or know, the Droid phone works well with the P3i application.					
COMMUNITY POLICING (CP)						
43	I have an intimate knowledge of the geographic area that I am assigned to.					
44	I value being in contact with the people who live, work or frequent my beat.					
45	The police cannot effectively deal with law enforcement issues without the help of the community.					
46	The primary duty of police officers is to control crime.					
47	Activities such as dealing with nuisance complaints or traffic problems get in the way of more important “real” police work.					
FEEDBACK re P3i						
48	The following feature(s) in the P3i application needs to be improved (please describe):					
49	The following features(s) should be added to P3i application (please describe):					

Appendix B: Focus Group Instrument

LPD Focus Group

Evaluation of location-based services for police: GPS-enabled cell phones and laptops for applications of law enforcement patrol.

I) Introduction

- Good morning
- Thank you for taking the time to meet with us. We will honor your time by making sure that we wrap up in the next 60 minutes.
- I am a researcher with the University of Nebraska Public Policy Center, and as you may all know, the Lincoln Police Department (LPD) has received a grant from the National Institute of Justice (NIJ).
- The purpose of the grant is to examine, laptop and hand-held computing devices that integrate geospatial technologies for use by Lincoln police officers.
- As part of the grant, the University of Nebraska Public Policy Center is conducting an evaluation to help LPD fine-tune and improve the P3i system. We are interested in your experiences with the system, both positive and negative, and your ideas about how it might be improved.
- All information we collect is confidential as to who provided it. For example, we will not disclose who actually participated in this focus group, and if we use quotes, we will not identify you by name and will not include any quotes that would identify someone. We hope that this anonymity encourages you (if you need encouragement) to speak freely.
- We value all your opinions, and hope that everyone will participate in the focus group and offer their ideas as well as listening to the ideas of others.
  Any questions before we start?

- *Be sure that everyone signs the consent form.*

II) Questionnaire to be addressed during focus groups:

1) How is P3i used in your daily operations? 2) Can you describe the benefits of P3i? 3) Can you describe the negative aspects of P3i? 4) Do you have any suggestions to improve P3i? 5) Do you feel more motivated at work because of the use of the software? 6) Have you noticed any impacts in your social lives because of the use of P3i? 7) Have you noticed any changes in miles driven since starting using P3i? 8) Would you recommend this software to others?