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Ethical Issues arising from the Real Time Tracking and Monitoring of People Using GPS-based Location Services

A. Mcnamee
University of Wollongong

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Abstract
The Global Positioning System is a constellation of 24 satellites which have the ability to calculate the position, time and velocity of any GPS receiver. Ethical concerns arise when a person carrying a receiver has their location transmitted to second party. This type of tracking has a wide variety of applications including tracking dementia sufferers, tracking parolees and law enforcement. A literature review found that the ethics of GPS tracking has not been thoroughly assessed. This paper investigates the ethical issues arising from the real time tracking of people using GPS-based location services. Usability context analysis and an observational study were the methodology used in this study. Usability context analysis provided insight into GPS tracking over the contexts of care, control and convenience. Its current applications could be seen in the tracking of Alzheimer's patients, parents tracking children, law enforcement, parolee and sex offenders, terrorist tracking, employee monitoring and commercial uses. A participant observational study was also used to develop an ethical discussion. It found five issues prevalent to GPS tracking: accuracy, editing track data, user travel behaviour, detail of GIS and user awareness. The results from the usability context analysis and participant observational study were used to form a discussion based on the issues of privacy, accuracy, property and accessibility.

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IACT450 – Information and Communication Honours Thesis

Andrew McNamee
2428866

Executive Summary

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Usability context analysis and an observational study were the methodology used in this study. Usability context analysis provided insight into GPS tracking over the contexts of care, control and convenience. Its current applications could be seen in the tracking of Alzheimer's patients, parents tracking children, law enforcement, parolee and sex offenders, terrorist tracking, employee monitoring and commercial uses. A participant observational study was also used to develop an ethical discussion. It found five issues prevalent to GPS tracking: accuracy, editing track data, user travel behaviour, detail of GIS and user awareness.

The results from the usability context analysis and participant observational study were used to form a discussion based on the issues of privacy, accuracy, property and accessibility.

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1. Introduction

1.1 Background

1.1.1 Location Based Services

Location based services (LBS) define the broad spectrum of technologies which can calculate the position of a receiver. There are many types of LBS which function at varying degrees of accuracy and scope. E911 is the most widely used LBS in the US which relays the location of mobile phone users to emergency units (whatis.com, 2001). The global positioning system (GPS) is an outdoor LBS which is capable of determining the location of a receiver within 15 to 100 metres of accuracy (Letham, 1999). GPS tracking and monitoring describes the use of GPS to determine the location of a receiver and consequently following its movements. This thesis will examine the ethical issues which arise from the ability of GPS to constantly track and monitor the movements of people.

1.1.2 Global Positioning System

The global positioning system is a constellation of 24 satellites circling the earth on 6 different orbital paths. These satellites orbit the earth once every 12 hours and in doing so have the ability to calculate the position, time and velocity of any GPS receiver (Letham, 1999). It does this through precise timing calculations and a method called triangulation. Triangulation works on the premise that you can find any position if the distance from three other locations is also known (Bajah et al., 2002). Initially conceived in the 1960's by the US Air Force it has cost $14 billion (GPSWorld) and took 35 years to create (Letham, 1999). In 1974, other branches of the US Military joined the project and it was declared operational in 1995 (Letham, 1999). Selective availability was initially imposed to limit signal accuracy for civilian usage but was revoked in 2000 (Bajah et al., 2002).

1.1.3 Current GPS Applications

Since the US Military made GPS available for civil use, the technology and its applications in the commercial sector have flourished. Today GPS is used for navigation,

scientific research, law enforcement, fleet monitoring as well as many leisure activities. The technology is so versatile it can be used for basically any outdoor activity. There are even golf GPS devices which display the layout of each hole and your location on the course (StarCaddy.com, 2003). Many new cars have GPS devices installed to assist in navigation (Holden, 2004) and car rental companies use them so a car's location can be found at all times. Scientists are using GPS to calculate the movement of tectonic plates, arctic ice sheets and volcanic activity (searchMobileComputing.com, 2003).

Products which monitor the movements of individuals are currently available in the US and have been available for some years. Wherify (2005) is a company which specialises in location based services and products. One of their products is the Wherifone (2005) which has a GPS receiver encapsulated inside a small mobile phone. This device does not need to be locked on to a person but instead relies on the individual's dependency on the phone. This is not too difficult in modern society as mobile phones have become so essential to our daily lives.

GPS is also useful to track the movements of certain groups of people. Alzheimer's and dementia sufferers can be tracked so they can be easily found if they ever wander (Shimizu et al, 2000). People under parole are sometimes ordered to wear GPS receivers so their current position is always known and to ensure they do not leave a certain area. Using GPS tracking for these and similar purposes is beneficial and are examples of how GPS can assist social groups.

1.1.4 Ethical Issues of GPS

A number of ethical issues arise from the rapid adoption of GPS technologies in society. Ethics is defined by the Pocket Macquarie Dictionary as "a system of moral principles, used to judge human action." The definition of morals is: "relating to or concerned with right conduct or the distinction between right or wrong." This study is aimed at determining whether the real time tracking and monitoring of people is morally right or wrong.

Using GPS simply as a navigation assistance device poses no ethical problems but when location data is transmitted to another location a number of problems arise. Perhaps the most significant ethical issue is that of privacy. As mentioned earlier, there are

already products available which can be used to track people's movements. These products disregard the privacy of the individuals who use them. Currently these products are imposed by parents or caregivers who have immediate authority. However, it needs to be asked what will happen if these sorts of devices become mandatory in society.

The legal issues of GPS tracking and monitoring is also concerning on a global scale. There are already laws which restrict this form of surveillance. In Australia, the Federal Privacy Act of 1998 outlines the basic forms of privacy which can be applied to LBS tracking. However, a court case in the US has allowed the use of a GPS device to prove a man guilty of murder (Bray, 2005). The judge ruled that there was "no Fourth Amendment implications in the use of the GPS device." The Fourth Amendment disallows police from searching people and property without a warrant. This means that any person suspected of a crime can have a GPS tracking device placed on him without his knowledge.

1.2 Existing literature/Previous research

1.2.1 Current Studies

The concept of tracking and monitoring using GPS technologies is far from novel. Numerous studies and experiments have investigated the potential of GPS to record a person's movements (Ashbrook & Starner, 2003 and Shimizu et al., 2000). However, very few studies have attempted to explore the ethical problems of GPS tracking.

One journal article entitled "Geoslavery", written by Jerome E. Dobson and Peter F. Fisher, stands out from other articles and is a point of reference for this study. It coins the term "geoslavery" as a "practice in which one entity, the master, coercively or surreptitiously monitors and exerts control over the physical location of another individual, the slave". While this article can be perceived as being overly paranoid it offers many deep insights into the possibility of "geoslavery" being present in the modern world as well as the future. The paper also refers to George Orwell's 1984 and compares many aspects of the novel to the real world. Despite this article's shortcomings its scope is merely based on a theoretical level with no reference to practical applications.

Another journal article entitled "Using GPS to learn significant locations and predict movement across multiple users" is also quite relevant to this study. As its name

suggests it analyses the potential of GPS to track and *predict* user movements. This ability to predict user movements is used to create detailed user models which can assist the user in daily tasks. The article uses complicated formulas and rationale not only to find their current location but also to deduce where they will move next. This study by Ashbrook and Starner is very technical and involves calculations which may not be relevant to this study. However, this article will still assist in the execution of certain sections of the observation study.

The article "Legal and Ethical Implications of Employee Location Monitoring" by Kaupins and Minch (2005) analyses the ethics of employee location monitoring. While it is only investigating the ethics of employee monitoring it is still very relevant to this study. Some ethical considerations identified by the article which encourage employee location monitoring are security, productivity, reputation and impact on third parties. Conversely, some ethical considerations which limit employee location monitoring are also identified as privacy, accuracy, inconsistency, right to examine records, informed consent.

1.2.2 Gap in the Literature

There is a gap in previous research and literature which suggests that the ethical issues of constant GPS tracking and monitoring have not been thoroughly assessed in academia. It has been shown that GPS is a very effective way to track and monitor the movements of people. However, the practicality of GPS tracking and how it affects people needs to be examined in detail. Most importantly, the individual's reaction to being tracked and monitored over long periods of time needs to be explored. This study will attempt to fill this gap in the literature.

1.3 Objectives

This study has four objectives:

1. Analyse existing literature in the field of GPS monitoring and tracking in order to ascertain current and potential uses of GPS;
2. Investigate the current uses and applications of GPS tracking through multiple usability context analysis;
3. Perform an observational study to find the practicality and implications of tracking a person using a GPS device; and
4. Use the findings obtained in objective two and three as a base to form a discussion on the ethical issues of GPS tracking and monitoring.

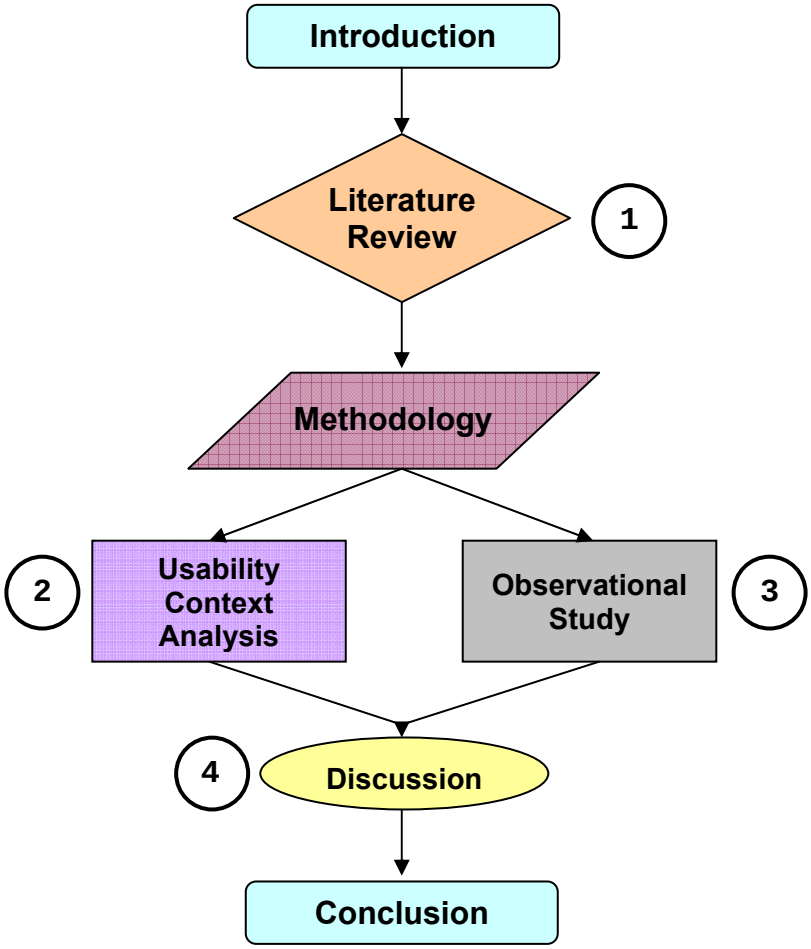


Fig 1.1 Model of study method

1.4 Methodology

This study will use a combination of usability context analysis and an observational study in order to gather results.

1.4.1 Usability Context Analysis

An investigation of three usability contexts will give a broad understanding of the ethical issues of GPS tracking and how it may affect society. These usability contexts will be care, control and convenience. As GPS is already an established and well documented technology, multiple usability context analysis will provide insight into where the technology is today and where it is likely to go in the future. Newspaper articles and websites will all help create a picture of the applications and issues relating to GPS.

1.4.2 Observational study

An observational study which tracks the movements of a person will provide deeper insight into GPS tracking than case studies alone. This study will be conducted over a two week period using a Magellan Meridan Gold Handheld GPS device. The GPS device will be carried by a single user and will be used to track his movements. At the end of each day the track nodes recorded on the device will be uploaded onto a PC for analysis. Coordinates can not be recorded while the user is indoors but the user's position will be assumed by their last recorded position.

The purpose of this observational study is to experience the invasiveness of GPS tracking and monitoring first hand. The study will also attempt to establish how an individual feels about being tracked constantly. His thoughts and opinions will be recorded in a diary or journal.

An ethical discussion based on the results of the above methodologies will answer questions based on privacy, accuracy, property and accessibility.

1.5 Limitations

Certain constraints will hinder the progress of this study and the experiment. While GPS can be accessed anywhere in the world this study will focus solely on tracking and monitoring in a single local area. Also due to ethical and financial reasons only one person will be tracked through the course of the experiment. During the experiment limitations imposed by the GPS technology like receiver reliability, indoor use and inaccuracies caused by tree canopies and buildings will need to be taken into account. Additionally, the experiment will take into account the receiver's lock-on time as the GPS will usually take around one minute to get an accurate reading (Christ, 1996).

This study will entail an exploration focusing on the ethical implications that GPS monitoring has on the countries most affected by it. Usability context scenarios will best illustrate how real time monitoring is being used in the USA, the primary user of the GPS system. The context analysis will also focus on its growing popularity in Australia, which is adopting the technology in a similar fashion.

1.6 Assumptions

Throughout this study the following assumptions will be made:

- GPS is the most accessible location based service currently available.
    - There are other location based services under development (eg. GALILEO) but they are not as popular or widespread as GPS currently is.
- It is possible to constantly and accurately track a person's movements using a GPS tracking device.
    - Even though GPS does not work indoors it still is possible to assume a person's approximate location depending on where the GPS signal was lost.
- GPS will continue to be more available to the general public in the near and distant future.
- A number of ethical and legal problems arise from constantly tracking people.

1.7 Justification

GPS technologies are becoming more commonly accepted in society. The price of GPS devices has dropped dramatically since the first commercial hand held device which cost $US3000 (Stead, 2001). Today a GPS device can be purchased for as little as $AU80 (Electronic Frontier, 2005). GPS offers many advantages to life and everyday living. Investigating the ethical implications which arise from GPS is imperative in order to fully understand how it will affect the world. GPS is already revolutionizing how we perceive the world today.

It is likely that GPS technology will follow a similar adoption pattern as mobile phone technologies. Today mobile phones are widely used and their popularity is always increasing. In 2002, 72 per cent of Australian households had access to a mobile phone (ABS, 2005). Mobile phones were originally expensive, bulky and unreliable but as the technology improved so too did users' acceptance. Now there is almost a technological reliance on mobile phones which inhibits people from deciding whether they actually need one or not. Society chooses for people because if they do not have a mobile phone they will be left behind. If you consider the adoption of mobile phones it is not difficult to conceive GPS technologies being adopted in a similar fashion. If GPS technologies are going to become part of society the impacts of the technology need to be assessed now.

Ironically, some new mobile phones already have GPS receivers installed in them. Convergence of GPS technologies with other technologies could become so common that they will be found in most electrical devices. It could possibly get to the stage where GPS devices are so cheap and small they will be installed in PDAs, laptops, cars, watches, phones and MP3 players as a standard feature. This will have massive implications for the privacy of individuals and could change social structures around the world.

The ethics of the real time tracking and monitoring of people needs to be investigated. GPS can track a person's movements both accurately and indefinitely. If GPS technology does become a mainstream part of society it will pose many issues.

2. Literature Review

2.1 Introduction

The purpose of this literature review is to develop an understanding of previous research and studies which relate to the ethical issues of GPS tracking and monitoring. It aims to fulfill the first objective specified in the first chapter: "Analyse existing literature in the field of GPS monitoring and tracking in order to ascertain current and potential uses of GPS."

2.2 Document Classification

Many articles had strong similarities with other articles and they could be classified into specific themes. These themes are applications, technological constraints, convergence, future applications and ethical issues. Each theme can be related to ethics; however, there were some articles which deal with the ethical issues of GPS tracking specifically. Below is a diagram of the literature review schema:

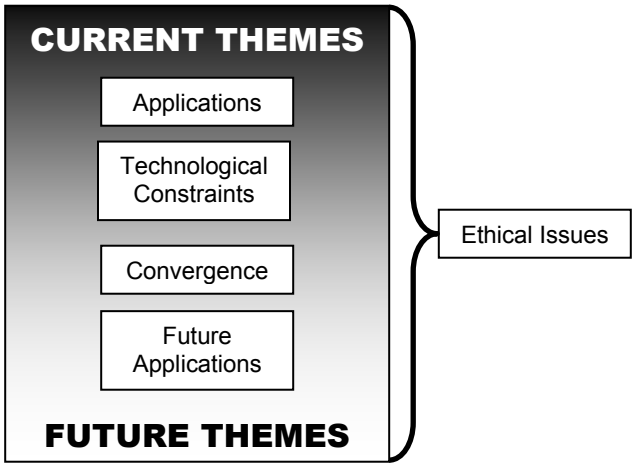


Fig 2.1 Literature review schema

2.3 Literature Analysis

As the ethics of GPS tracking will continue to be an important issue in the distant future, each theme is ordered by their relative importance today. Analysing the applications of GPS indicates there are many limitations to the technology. While these limitations are being addressed by researchers and manufacturers it is unlikely that the technology will ever be fault free. Convergence of GPS and other technology will eliminate many technological limitations and in turn will create future applications. These issues can be assessed individually or as a whole to determine any ethical and legal issues. Themes which are more relevant in the present time are ordered earlier than themes which will be important in the future.

Theme	Previous Research
Applications	(Christ 1996; Letham 1998; Shimizu K. 2000; Stread 2001; Janice Loh 2004; McNamara 2004)
Technological Constraints	(Enge 1999; Bajaj 2002; Diep Dao 2002; Wang 2003)
Convergence	(Thomas 1998; Koshima 2000; Michael 2004)
Future Applications	(Won Namgoong & Meng 2000; Starner 2003)
Ethical Issues	(Mason 1986; Dobson 2003; Owen 2004; Kaupins 2005)

2.4 Applications

Most of the literature available can be classified into this theme. Nearly all articles concerning GPS describe its applications to some degree. Many books describe the recreational uses and features of GPS devices. Two books which act as user guides to introduce people to GPS devices are “GPS for Dummies” (McNamara 2004) and “GPS Made Easy: Using Global Positioning Systems in the outdoors” (Letham 1998). Both books state that GPS can be used for activities like geocaching, fishing, hunting, flying, boating and hiking. They also provide information on GPS devices which are best suited for certain activities and useful software which can be used in conjunction with a device. These books, however, are merely user guides and do not touch on topics such as location monitoring and the ethical issues which entail.

2.4.1 Beneficial Applications

Aside from recreational uses GPS devices can also be extremely beneficial to a number of social groups. Two articles which recognise the benefits of GPS in tracking wandering dementia patients are "Technology Applied to Address Difficulties of Alzheimer Patients and Their Partners" (Janice Loh 2004) and "Location System for Dementia Wandering" (Shimizu K. 2000).

Both articles recognise that there is an ageing population. The first article introduces the issue of an ageing population in the Western world by providing statistics of the Netherlands population. 6.6% of the population aged 65 and over suffer from dementia. Of these people 40 to 60% suffer from Alzheimer's disease. The article "Location System for Dementia Wandering" also recognises an increase in the number of older people by stating that the ratio of elderly people in Japan is rising. This indicates that the issue of an older population is a global issue.

Loh recognises that patients wander during blackouts which are "characterised by disorientation due to this temporary memory loss." The purpose of the study is to "bring together the technological possibilities with needs of the people and create an appropriate solution by means of a device." It does this by creating a program called "Guide Me" which had two parts.

The first part of the study is to gather information about the properties and problems caused by Alzheimer disease. This part was conducted by interviewing Alzheimer sufferers and it was found that most patients are aware of their limitations but still want to remain socially active people. The second part was entitled "research testing for concept development". A prototype GPS device was carried by a patient as they carried out daily routines. A caregiver monitored his/her movements through a PC. This simulation found the following results:

1. The caregiver does not require location information of the patient at all times;
2. The caregiver wants to know if the patient is having a blackout and wandering the streets;
3. The patient did not want to be intrusively contacted, for example by incessant phone calls, whenever the partner wanted to know the patient's whereabouts;

4. Both parties agreed that there should be no excessive communication. The communication should be subtle and only when needed;
5. In emergency situations, the initiative of tracking should lie upon the caregiver;
6. The patient should carry or wear the transmitting device at all times since blackouts can occur anytime;
7. The device worn by the patient should not be designed as a stigmatizing tag.

The article also gave credit to the inspiration of the Guide Me project which came from two products called "Digital Angel" and "Tracking Watches". While these devices are not aimed at elderly people the Guide Me prototype aimed to fulfill the needs of Alzheimer's sufferers.

User feedback from Alzheimer's suffers indicated that a device with a basic simplistic design was important. Users also commented that the device can alleviate stress for families and relatives. In fact, positive feedback was given by caregivers and patients alike. However, a shortcoming of the device was found in the fact that patients may forget to put on clip-on device. A suggested solution to this was to use a permanently worn device, like an implant or watch. However, this raises some ethical issues such as user consent and privacy.

The Guide Me project described in this article showed that GPS could be applied to a needy cause. In the study, Alzheimer's patients were not tested with prototypes, only their opinions were given. The authors suggested that this study is a stepping stone to further research. This article also relates to the theme of convergence as the devices used in the prototype were made from a combination of GPS and GSM (global system for mobile communications) technologies.

The article "Location System of Dementia Wandering" used a GPS and a mobile phone system to discover the practical applications of tracking dementia patients. This paper:

> "…presents the outline of this technique, some results of a feasibility study, and some techniques devised to solve the practical problems."

The authors recognise that there are two techniques to handle dementia wandering. Either detect when a patient is going out of a protected area or constantly

monitor the movements of the patient. Similar to the previous article an observational study was carried out where a responder (device with mobile phone and GPS capabilities) was carried by a patient. When the helper realises the patient is missing they ring the responder which calculates the GPS co-ordinates and relays it back to a PC which the helper can view.

A number of problems and limitations were recognised with this location system. A feasibility study deduced that the GPS receiver orientation and tall buildings had an effect on the experiment. Additionally problems were caused by environmental conditions, like large snowflakes, which disrupted signals. Blind spots and momentary disconnection were also experienced when users entered buildings. This was remedied by using the last received waypoint to determine their location. Low levels of accuracy of 100 to 200 metres caused more problems but a solution was offered in the form of differential GPS. These problems indicate many limitations to using GPS to track dementia wanderers but some solutions are provided. Both articles recognise a beneficial use for GPS tracking; however, they also recognise some limitations imposed by the technology.

2.5 Technological Constraints

Many articles refer to the technological constraints of GPS technology. These constraints include indoor dropouts, limited accuracy and insufficient security. However, many researchers are developing means of overcoming these limitations.

2.5.1 Indoor Usage

One constraint of GPS recognised by previous articles is that it cannot be used indoors. Many articles have researched the possibility of using existing wireless technologies to create an indoors wireless positioning system to be used in conjunction with GPS (Diggelen 2002; Dhruv Pandya 2003; Wang 2003). The article: “An indoors Wireless positioning system based on WLAN infrastructure” recognises that “there is still a need for other positioning technologies to remedy the serious shortcomings of GPS technology.” It states that indoor positioning has been overlooked by researchers due to limited market demand and an incomplete infrastructure. However, an increasing wireless communications network infrastructure and increasing interest has conjured the need for

"an accurate location-finding technique for indoors." The authors used an experiment to test this theory by using six WLAN access points and PDAs with wireless network cards. They carried out a number of tests to determine the effectiveness of this LBS. A stability test found that transmitted signals were stable, consistent and therefore able to be used for measuring. A reliability test found that an accuracy level 1 to 3 metres was possible and, under idealized situations, it was possible to get position accuracy to the 0.1 metre level. A wall penetration experiment found that there was a small amount of signal loss as they propagated through walls. This article found that a wireless access point-based indoor positioning system is feasible but further research would be needed. This paper shows that combining GPS and wireless networking technologies can allow GPS to be used indoors.

2.5.2 Accuracy

"GPS: Location tracking technology" recognise that environmental factors like water vapor and other particles can slow down signals. Signals can also bounce off buildings and trees to cause inaccuracies. The author also recognises that selective availability (SA), imposed by the US military limited GPS accuracy until it was deactivated in 2000. Two methods are described to improve GPS accuracy: DGPS and AGPS. Differential GPS works by employing "both roving receivers that make satellite position measurements and stationary receivers that use their position to compute signal timing." Assisted GPS uses existing technologies like Bluetooth and wireless networks to relay relevant location data to the GPS receiver. AGPS indicates convergence between various technologies to overcome accuracy limitations of GPS.

"Location-based services: technical and business issues" by Dao, Rizos and Wang recognises interoperability as "a must for the widespread adoption of location-based services." It states that interoperability, or convergence, ensures network security, privacy as well as facilitating billing and revenue sharing. It recognises that interoperability needs to be addressed across wireless networks, positioning technologies, core networks and applications. It seems that the limitations of GPS will be addressed through convergence.

2.6 Convergence

The mass adoption of GPS and LBS will depend on the convergence of existing technologies such as PDAs, laptops and mobile phones. The articles which apply to this theme demonstrate that GPS technology is converging with other technologies to improve functionality and eliminate limitations.

The article "Location Based Services: a Vehicle for IT&T Convergence" refers to LBS and convergence specifically. The author, Katina Michael, aims "to show the current state of development in leading edge LBS product innovations and to demonstrate that LBS have served to bring together information technology and telecommunications (IT&T) industries." It presents case studies of three companies which "offer product innovations that represent the diverse ways that LBS applications can be implemented." The first product is the AT&T mMode which offers LBS through devices such as IP-enabled phones, PDAs and handhelds. However, the mMode does not use GPS and offers very limited location accuracy. The two other devices described are the Wherify GPS Personal Locator and the VeriChip from Applied Digital Solutions. These two devices use GPS devices to provide superior accuracy over the mMode. The Wherify GPS Personal Locator is a wristwatch which is worn by a user while the VeriChip is implanted into a user's skin. These devices are being used in conjunction with geographical information systems (GIS) to produce detailed maps of a user's location. The author deduces that a *"convergence in complements* is occurring, given the products are working better together than separately." The article concludes with the notion that the convergence of LBS technologies will provoke cultural change in society.

The article "Personal Locator Services Emerge" indicates that the convergence of GPS technology is necessary to produce an effective personal location service (PLS). A PLS architecture is likely to involve a service provider, location center and a wireless network. Methods to improve GPS technology is described in the form of forward link trilateration which uses GPS satellites in combination with cellular base stations to calculate a location. This article, like the dementia articles mentioned earlier, recognises the problem of an ageing population. It states that there is an increased need for location monitoring services for the elderly with Alzheimer's disease. In the US it costs $30 000 per year to care for a patient in a retirement home. However, locator services are able to

reduce this cost. It also describes probation programs which use GPS technologies: “The goal is to verify that parolees and probationers comply with the directives imposed by the corrections system as to where and when they should and should not be by day and night.”

The article concludes with the notion that more work has to be done to improve: “accuracy, locator miniaturization, battery life, multipath effects, ability to penetrate buildings, and the economical use of RF bandwidth.” Advances such as assisted GPS are making these improvements. “Obviously, technical and commercial considerations will determine the success of the technology. Issues of user privacy and confidentiality will, however, have to he addressed first.”

2.6.1 Wearable Computers

A wearable computer is a concept which is increasing in popularity and relies on the convergence of existing technologies. The article “A wearable computer system with augmented reality to support terrestrial navigation” depicts a prototype of a wearable computer which incorporates many technologies, including GPS. It uses a heads up display to relay navigational information to the user. The navigational information is generated using a GPS receiver. This article gives an indication of how GPS can converge with other technology to produce new applications.

All the articles which analyse the convergence of GPS technologies deal with some possible future applications. However, truly unique concepts have been classed into the theme of future applications.

2.7 Future Applications

Studies which investigate the full potential or attempt to improve the functionality of GPS are covered by this theme. These articles indicate that the limitations of GPS technologies will be eradicated through convergence. They are very recent, having been completed in the last five years. Usually any studies which are older than five years investigate applications of GPS that have already been achieved.

2.7.1 User modeling

An article written by D. Ashbrook and T. Starner indicates a unique and promising application for GPS technology. Its subject matter is very relevant to the observational study described in the first chapter of this thesis (section 1.4.2). The article titled "Using GPS to learn significant locations and predict movement across multiple users" involves an observational study which uses GPS devices to generate user models. They define user modeling as "the acquisition or exploitation of explicit, consultable models of either the human users of systems or the computational agents which constitute the systems." The purpose of the study is to "describe research investigating one facet of user modeling, that of location."

The types of user modeling applications are identified as single user and multi-user. Single user models are used to notify a user of things to do from a pre-made list. For example, a single user model will remind the user to do some shopping if they are approaching a store. On the other hand, a multi user model will share location models in order to improve user convenience. For example, if one person wants to meet another person the technology will notify them when they are close to each other. Multi user models have endless possibilities. They can also be used to set up meetings and allow people with similar interests to meet.

Two separate studies were carried out: a pilot study (to develop algorithms) and the final study. The pilot study tracked the movements of a single user for 4 months in Atlanta Georgia. A Garmin model 35-LVS wearable GPS receiver and a GPS data logger were used to record latitude and longitude coordinates as well as the date and time. This data was recorded once every second but only if the receiver had a valid signal and was moving one mph or faster.

The article described the methodology used in this pilot phase. The first step was to find any significant places visited by the user by analysing the geographical data collected. They defined a 'place' to be "any logged GPS coordinate with an interval of time t between it and the previous point" with t equaling ten minutes. This means that if the user stayed in any one location for ten minutes or more the coordinates were defined as a 'place'. The next step was to define 'locations' by clustering various 'places' together using a k-means clustering algorithm. 'Sub-locations', which are basically

locations inside locations, were also defined. This was achieved by applying the same clustering algorithm within each location. For example, the location of "Campus" will have sub locations of "Physics building", "Library" and "IT building". The final step involved predicting the movements of a user. A Markov model was applied to each 'location' which transitions to another 'location'. The model generated the relative probabilities of moving from one location to another based on the location data.

The pilot paved way for the final study which was conducted in Zürich, Sweden. This study followed the movements of six users for seven months. They used the same equipment that was used in the pilot study but because more coordinates were to be taken they were all given a memory and battery upgrade. Some user problems were experienced as people often forgot to charge batteries and wear the device. Technology problems were also found in the form of spurious data points. This study made changes to methodology so that a 'place' would be registered when the GPS signal is lost. Aside from this change all of the same prediction algorithms were used in this study. It was found that the algorithms used in both studies gave consistent results across all subjects.

Ashbrook and Starner will use this study for future research in the form of time prediction. They believe they have perfected location predication to a level that it will be possible to predict *when* a person will move next. Future research will also look into extending the technology by incorporating a user interface and applications like to-do lists. The study has successfully proven "how locations of significance can be automatically learned from GPS data at multiple scales… [and] a system … can incorporate these locations into a predictive model of the user's movements."

This article is very relevant to the field study introduced in the first chapter. The article touched on some issues of privacy but the article's main concern was its methodology. The methodology and algorithms used will be very useful to this study. However, location prediction extends the scope of the field study. The author aims to have this form of technology available to the general public: "One day, such predictive models might become an integral part of intelligent wearable agents." Indeed, it is feasible that this type of technology will be available in the future but before it does guidelines and security measures need to be addressed. This article is an indication of future developments in GPS tracking and monitoring.

GPS receivers are becoming smaller and more portable. An article that demonstrates this is “GPS reciever design for portable applications.” This article is quite technical but illustrates how to effectively reduce power consumption and increase the level of integration of a reciever. The article concludes: “This low power and highly integrated design enables the implementation of numerous new applications, especially of the portable/wearable variety, that are simply impractical with existing solutions.”

2.8 Ethical Issues

After the applications, limitations, convergence and future limitations are understood we can consider the ethical and legal issues concerning GPS tracking as a whole.

2.8.1 Ethical Framework

The article “Four Ethical Issues of the Information Age” develops an understanding of ethics in relation to IT. These four issues are privacy, accuracy, property and accessibility. While this article does not refer to LBS or GPS at all it is still applicable to the ethics of tracking a person 24x7. The issue of privacy is important as geographical data collected by GPS devices can be misused if they fall into the wrong hands. A possible solution to this is the encryption of geographical data. The varying accuracy of GPS devices means location data is not always reliable. GPS location data must be accurate if it is to be considered a viable data source.

The issue of property can be used to ask who actually owns the GPS infrastructure. The US Military may have developed the system and deployed the satellites but they have little influence since the removal of selective availability. The companies who manufacture and sell GPS devices have a growing responsibility. It must be asked whether a monopoly will ever ensue from company success. The final issue of accessibility is also quite relevant. As GPS technologies become more available it is quite possible that a technology gap will grow between people who have access and those who do not. Although this article was written nearly two decades ago it is still quite relevant to the issue of GPS tracking today.

2.8.2 Geoslavery

Another article titled "Geoslavery" is a landmark study in the issue of location monitoring and ethics. The purpose of the article is to "explore [the] possibilities for mis-use [of LBS] that many would consider unethical" (Dobson 2003). Dobson and Fisher wrote this article in an attempt to "forewarn the public, foster debate, and propose remedies." The unique term, geoslavery, is coined and described as the "practice in which one entity, the master, coercively or surreptitiously monitors and exerts control over the physical location of another individual, the slave." The authors recognise that current commercial products can be used for geoslavery but "no government has yet established any specific statutes or regulations restricting their use."(Dobson 2003) In fact, only a GPS receiver, radio transmitter and a GIS is needed. The only necessary addition to make geoslavery a reality is a transponder which can shock or injure the recipient. The fact that there is no technical challenge in doing this is made very apparent. Some companies which manufacture products that can be used for geoslavery are identified: Wherify, Digital Angel and Travel Eyes. The article mentions that British and US prisoners on parole are tracked using GPS bracelets. Tracking prisoners is justified because "having their liberty curtailed is part of the criminal justice system." Geoslavery is described as a threat to basic human rights. If it occurs it will breach numerous articles of the *Universal Declaration of Human Rights* and parts of the *Declaration of the Rights of the Child.* Women's rights are also threatened by geoslavery in some cultures which restrict the rights of women.

The authors recognise that global leaders have a social responsibility to prevent geoslavery ever becoming a reality. They state that technology is neither good nor evil but it can empower those who choose to engage in good or bad behaviour. They also demonstrate that attitudes to technology can change over time. For example, security cameras will seem less of a threat to children who are growing up today as they are all around them. The article compares aspects of geoslavery to George Orwell's novel "1984" and Big Brother surveillance. A theme of "1984" was the notion that surveillance can confer control which is why the government in the novel imposed strict surveillance. However, although geoslavery may be used as a means of control by governments the greatest threat is the individual's use of the technology.

LBS technology is described as the "quintessential double-edged sword." It makes like easier for businesses tracking goods, parents caring for children and people caring for Alzheimer's patients but many ethical issues entail. Dobson and Fisher recognise that "the challenge is to develop safeguards that simultaneously permit legitimate uses while preventing mis-uses."

The article concludes with a comparison between LBS and nuclear energy. Both offer great advantages but in turn are incredibly risky. The authors comment on the predicament of these technologies: "Invent something dangerous enough, and screw it up badly enough, and you'll have a job forever."

"Geoslavery" is an important article written by experienced authors in the field of GIS. It offers the truly unique concept of geoslavery which is of great relevance and importance to this study. The article may be perceived to be overly paranoid as some dramatic predictions are made about the future of LBS technology. For instance, the authors compare LBS to nuclear energy in relation to the benefits and risks it possesses. However, this analogy has some drawbacks. Nuclear energy has lead to the creation of the atomic bomb which has killed thousands of people. It is unlikely GPS devices will ever kill one person yet alone a thousand people. On the other hand, the author's appeal to governments and industries to create frameworks and safeguards is justified.

2.8.3 Real World Issues

A recent article written by Kaupins and Minch examines both the legal and ethical implications of employee monitoring. The authors simply aim to "examine a number of important legal and ethical implications of employee location monitoring." It identifies the fact location technologies are becoming more pervasive because of drops in cost, government mandates and marketplace factors. In fact, it is estimated that 80% of new vehicles will be equipped with location aware technology by 2006. Legal implications of LBS pervasivesness are recognised in the statement that "the right of an individual (whether [s]he be an employee or not) to location privacy has not been clearly established anywhere in the world." Some acts have attempted this but were not passed.

Some ethical considerations identified by the article which encourage employee location monitoring are security, productivity, reputation and impact on third parties.

Ethical considerations which limit employee location monitoring are also identified: privacy, accuracy, inconsistency, right to examine records, informed consent.

The authors conclude that further research of the legal and ethical issues in location monitoring need to be discussed. They suggest that this is best achieved through case analysis and survey research.

This article is primarily focused on US laws but it is still relevant to Australia and the rest of the world. The issue of employee location monitoring is quite relevant to the ethics of real time tracking. The legal and ethical arguments presented in the article are very relevant to the tracking of people in general, not just employees.

2.9 Gap in the Literature

There is an abundance of articles articulating the applications of GPS devices. Many articles detail the limitations of GPS technology and provide solutions in the form of converging it with existing technology. Some articles have truly original concepts of future applications which are made possible through convergence. While many articles touch briefly on the ethical issues of GPS tracking very few have it as their primary subject matter. “Geoslavery” is an important article relating to the issue of GPS tracking but is merely theoretical. A gap in the literature is existent from the lack of literature which details ethical implications of GPS tracking and monitoring. The literature also indicates that this will continue to be an important issue in the future as GPS technology becomes more widespread.

2.10 Conclusion

This literature review has recognised that there is a need for a study detailing the ethical issues arising from GPS tracking and monitoring. The literature schema details the themes that relevant literature can be classified into. The current applications of GPS devices are heavily documented and indicates the limitations of GPS devices. However, convergence, in the form of AGPS, DGPS and other methods, will remedy most of these limitations. This in turn will pave the way for future applications which may have some unforeseen consequenses. The ethical issues of GPS tracking and monitoring apply to all of these themes and they will grow in importance in years to come.

The issue of an ageing population was mentioned in many articles which justifies the use of GPS among dementia sufferers. It appears this will continue to be an important issue in the future. Also, many articles referred to location based services in a broad sense and only mentioned GPS as a part of location based services. It was found that location based services usually consists of a combination of GPS and mobile phone technologies. Products like Verichip and Wherify Personal Locator appeared in many articles. The Digital Angel product which is implanted into a user's skin is also described by many authors. However, the company which produces this product, Advanced Digital Solutions, no longer makes it available to people, only animals.

3. Methodology

3.1 Introduction

The purpose of this chapter is to describe the methods that are to be used in this study. It will describe the methods that will be used to satisfy objectives two and three (section 1.3) by describing how this study will investigate the ethical issues which arise from the real time GPS tracking and monitoring of people. This study is a clarification of this issue where the main purpose is to identify the dilemma posed by having sophisticated LBS technology that can be used for both good and bad intentions.

A usability context analysis will give insight into the current uses GPS tracking technology. An observational study will provide a practical perspective of the tracking process. These two methodologies will be combined to create a discussion on the ethics of GPS tracking.

3.2 Research Approach

An exploratory approach is best suited to this study and its purpose. Some of the ethical issues of LBS tracking have been touched on by some researchers and social commentators (Dobson 2003; Owen 2004; Kaupins 2005). However, the issues have been investigated on a theoretical level. For this reason an explanatory approach will be pointless in determining ethical issues arising from GPS tracking. Instead this study must investigate these issues and their implications through exploratory methods.

A qualitative approach is essential in collecting data as ethics is best interpreted from collections of ideas, thoughts and opinions which are easily communicated through the forms of speech and text. Geographical data in this study will be quantitative as it is collected as latitudinal and longitudinal coordinates. However, this data can easily be interpreted as qualitative data by interpreting the coordinates to a specific location.

The ethics of GPS tracking is dependent on how the technology is being used. For this reason the unit of study will be classified by its “application areas”. An application area can vary from employee tracking to law enforcement. Due to the exploratory approach of this study the data will only be collected once. If data were to be collected on multiple occasions they will differ slightly but the results will likely turn out to be the

same. This will be a cross sectional study where all the data will be gathered in this single study period only.

3.3 Research Methods

3.3.1 Usability Context Analysis

Similar to case studies, a usability context analysis will be used to develop an understanding of the attitudes and opinions held by various stakeholders. Yin (1994, p.13) describes a case study "as an empirical inquiry that investigates a contemporary phenomenon within its real life context." The author (Yin 1994) also describes case studies to be an effective research strategy when:

- the type of a research question is based on "how" and "why" questions
- there is little control over behavioral events
- the study focuses on contemporary issues

This study can be classified by all of these instances. The research question is dealing with problems of *how* GPS technology can be misused and *why* it is allowed to be misused. The study is not concerned with *what* the ethical issues are, they are already recognised. Additionally, there is little control over the behavioral events of real time tracking and monitoring. The accessibility of GPS technology means that it can be used by anyone who can afford a device. This study also deals with a contemporary issue which has only become known since GPS was made available for civilian use.

Three usability contexts have been specially chosen to encompass the most relevant GPS applications which can cause ethical dilemmas. These usability contexts are care, control and convenience.

3.3.2 Observational Study

The best way to deduce some of the unforeseen consequences of GPS tracking is to experience the process first hand. An observational study involving participant observation will be very effective in understanding how a person forced to have their movements tracked and monitored may respond. This practical component can also be adapted to real world scenarios. Hopefully, some ethical issues which have been previously overlooked may also arise from this study.

This observational study will be best carried out through participant observation. Participant observation is where the observer "seeks to become some kind of member of the observed group" (Robson 2002). For the purposes of this study the *observed group* encompasses all individuals who would have their movements tracked and monitored by a second party. This observational study will involve a single participant observer in order to empathise with this group of people. Hopefully this method will conjure similar social habits and scenarios. This form of participant observation has been chosen due to the accessibility of GPS technology. Ethical considerations would hinder the structured observation of a large group of people. Additionally, financial constraints limit the number of GPS devices available. For these reasons observing a large group of users will not be possible.

An observational study allows for the observation of daily events and lifestyles as they occur naturally (Hyland, 2005). However, a great deal of care must be taken to ensure that the observational study does not affect the participant observer's daily practices. There is a significant chance that self imposed observation may have a Hawthorne-like influence on the outcomes of this study. Measures need to be taken to ensure the participant observer's normal activities are not impacted in any way.

Due to the chance of inconsistencies developing throughout the observational study a pilot study will be carried out beforehand. This will be essential in order to test any unforeseen shortcomings to the methods. This will also provide an opportunity for any corrections that need to be made to the observational study. Additionally, issues such as battery life, device failure and black spots will also be experienced and dealt with in

the most appropriate manner. After the results of the pilot study are analysed the observational study will commence.

Two sets of data are to be gathered throughout this observational study: geographical co-ordinates and diary logs. The geographical coordinates will be collected through the means of a GPS device as quantitative data. However, in order to make sense of this data GIS software will be used to transform co-ordinates into qualitative data. This data will also be analysed using the GIS software. The diary logs will be collected as qualitative data. Each day during the study the participant will record any thoughts and opinions they may have.

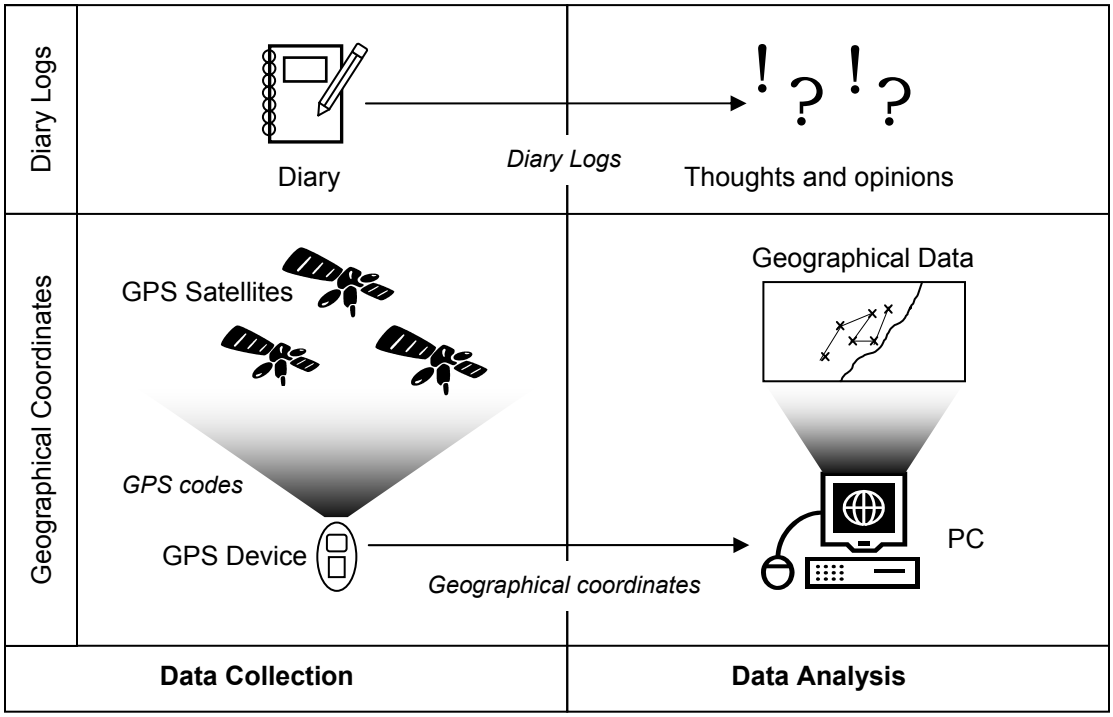


Fig 3.1 Observational study model

3.4 Ethical Discussion

The results of the usability context analysis and observational study will be combined to create an ethical discussion based on four criteria: privacy, accuracy, property and accessibility. This ethical framework is based on the work of Mason (1986), Mason et. al. (1995) and Turban (2002).

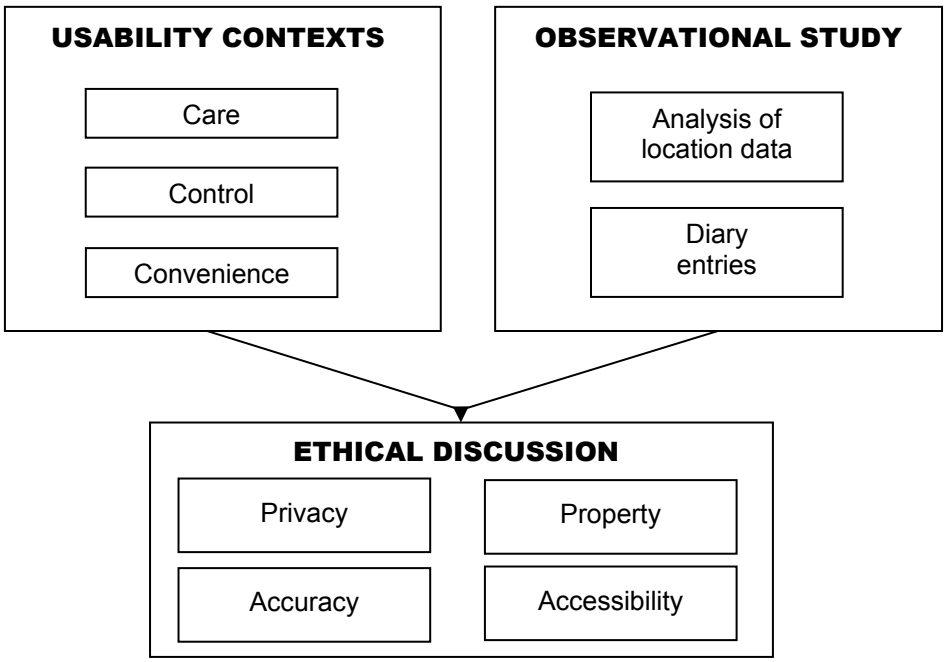


Fig 3.2 Forming an ethical discussion

3.5 Conclusion

The research design and methodology depicted in this chapter were selected to complement the issues of this study. The observational study and the multiple usability context analysis give two very different view points. The observational study will demonstrate the point of view of a person who is having his own movements monitored. On the other hand, the usability case analysis will provide insight into the view point of the groups of people who monitor other people's movements. These two view points will create an understanding of the problem as a whole. The observational study and usability context analysis will be described in the next two chapters. The completion of both of these studies will make way for a discussion of the ethical issues of real time GPS tracking and monitoring.

4. Usability Context Analysis

4.1 Introduction

This analysis will investigate the current uses and applications of GPS tracking through usability context analysis (objective 2). Three usability contexts of care, control and convenience will be analysed. The usability context analysis is based on the methodology of a study conducted by Amy Masters which investigated human centric application of radio frequency identification tags (Masters, 2003). Each context will focus on uses of GPS tracking in the USA, which is the principal user of GPS products, and Australia, which seems to be following in the footsteps of the US.

4.2 Care

GPS satellite tracking can assist people who are responsible for the health and wellbeing of others. Two common forms of care tracking using GPS is the tracking of dementia wanderings and parents tracking their children.

4.2.1 Dementia Wandering

The Alzheimer's Society defines dementia as:

> "a term used to describe various different brain disorders that have in common a loss of brain function that is usually progressive and eventually severe."

Dementia is a symptom of a number of diseases. However, the most common are Alzheimer's disease, vascular dementia and dementia with Lewy bodies (Alzheimer's Society, 2005). It currently affects 5 per cent of people aged over 65 years and 20 per cent of people over 80 years of age (Alzheimer's Society, 2005). Cases of dementia are increasing and it is expected that the number of dementia sufferers will nearly double by the year 2025[1] (Alzheimer's Society, 2005).

Dementia becomes a serious problem when a patient begins to wander. Due to his/her mental state a dementia sufferer may get lost quite easily and may even be injured or killed (Project Lifesaver, 2005). Since it is difficult to keep constant watch over a

[1] Based on the current 18 million people with dementia and the forecasted 34 million people worldwide

dementia sufferer a caregiver can employ a variety of assistive technologies including GPS trackers.

The unpredictable nature of dementia means that a sufferer must carry a GPS receiver at all times in order to be effective. A tracking system could be set up so that if the person with dementia began to wander a caregiver or family member would be notified automatically by phone, email or message (Loh, 2004). It would then be a simple case of discovering their location at a tracking base station.

Tracking dementia sufferers with GPS offers a cheap, ad-hoc solution to a very serious problem. This type of system does not require a caregiver to look after patients 24/7 so dementia patients have more independence and freedom allowing them a better quality of life (Loh, 2004). Also, GPS tracking eases the burden off the ailing aged care sector because a single caregiver can look after numerous patients.

4.2.2 Parents tracking children

Some parents use GPS trackers with their children for security reasons. Many parents are worried about losing their children in a car accident or abduction. GPS offers a means for parents to monitor the activities of their children even when they are away from home.

There are many GPS products available today which allow parents to do this. One of the more popular products is *Wherifone* created by US company Wherify Wireless (Wherify, 2005). The device is small, even for a telephone, being about the size of a credit card (Yeebo, 2005) and has a 911 feature which alerts emergency services (Wherify, 2005). Previously, the company offered a wristwatch tracker but discontinued production because customers wanted to be able to call their children (Yeebo, 2005). Users can find the location of the child by logging on the company website and viewing their location on a map (Wherify, 2005). Aside from tracking children Wherify also markets the device for seniors, work employees and even pets (Wherify, 2005).

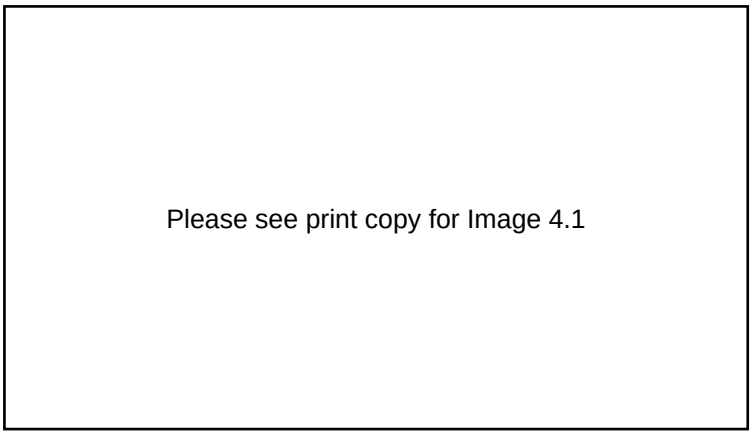


Image 4.1 The Wherifone (Anonomous, 2005)

The *Teen Arrive Alive* program is a US organisation that is "dedicated to addressing teen driving safety" (Teen Arrive Alive, 2005). One of the services it provides is TAA GPS where parents can find the location of their teenage child using GPS technology. For $US19.99 a month parents can track their teenager either online or by calling the locator hotline (Teen Arrive Alive, 2005). Locations are updated every two minutes so parents can keep a watchful eye on their child's activities. This service is possible through a partnership of Nextel phones and uLocate Communications (Yeebo, 2005). *MapQuest Find Me* is a similar service which also works on Nextel phones along with Java enabled phones and Blackberry devices (Yeebo, 2005).

In Australia, parental tracking is not as widely accepted but its usage is growing daily. One GPS device, called *Ezitrack* can allow parents to immobilise a car while it is moving (Benns, 2005). Even though the device gives a 90 second warning before the car shuts down officials are still concerned saying it is dangerous, causes inconvenience and "puts (policing) in the hands of the individual" (Benns, 2005). A South Australian primary school is also using a GPS tracking system on their school bus to monitor speed and keep track of where children get off the bus (ABC, 2005).

4.3 Control

Most ethical problems are connected to the control aspect of GPS tracking devices as it imposes a very intrusive method of supervision. Three areas which GPS is widely used are law enforcement, parolee and sex offenders, suspected terrorists and employee tracking.

4.3.1 Law Enforcement

US law specifies that a court can issue a warrant for the installation of a mobile "tracking device" if a person is suspected of committing a crime (Legal Information Institute, 2005). The term "tracking device" covers a broad spectrum of technologies but the popularity and simplicity of GPS makes it a definite inclusion in this spectrum. There are an increasing number of cases in the US of police officers planting GPS devices on suspected criminals. The GPS tracking data is being used as evidence in legal trials and judges are pronouncing people guilty of crimes based on this evidence. However, there are inconsistencies in the US legal system.

The William Jackson case, in Spokane USA, was the first to rule that placing a GPS device on a person or their vehicle does not require a warrant as it is the same as following them around (George, 2003). In 2000 Jackson was found guilty of murdering his daughter after the GPS device placed on his truck found that he had returned to his daughter's burial spot (George, 2003). In another case in New York the judge ruled that police do not need a warrant to track a person on a public street stating that the defendant:

> "… had no expectation of privacy in the whereabouts of his vehicle on a public roadway." (McCullagh, 2005)

Another case involving a tracked suspect had legitimately placed a GPS tracker after the issuing of a warrant. In San Francisco, Scott Peterson had a GPS tracking device placed on his car after being suspected of murdering his pregnant wife in 2002 (Dornin, 2004). His suspicious behaviour led to a legal trial involving much speculation over the positioning of the GPS antenna and the accuracy of the collected data (Finz and Taylor, 2004). However, the judge said that the technology "is generally accepted and fundamentally valid" (Dornin, 2004). Despite this Peterson was eventually found guilty

of murder by the jury based not on GPS evidence but on his emotional indifference (MSNBC.com, 2004).

4.3.2 Parolees and Sex Offenders

Another use of GPS tracking devices which is growing in popularity is the tracking of parolees and sex offenders. Tracked parolees are usually fitted with a small tamper proof GPS tracker worn as a bracelet or anklet. Tracking parolees and sex offenders in this way can ensure they do not commit any crimes, alert authorities if they enter certain locations, like schools or parks and prevent them from leaving their homes if that is forbidden (Monmonier, 2002).

Parolee and pedophile tracking is widespread in the United States with an estimated 120 000 tracked parolees (Saletan, 2005) in 28 states (Hatzistergos, 2005). However, there are over 50 000 convicted sex offenders in the US that are not tracked at all (Scarborough Country, 2005). Australian states have been trialing GPS systems and there are proposed schemes for NSW, Western Australia and Victoria (Murphy, 2005). In NSW there are 1900 offenders on the Child Protection Register but officials say it is too costly and difficult to track all of them (Vermeer, 2005).

There is a great financial incentive to impose GPS tracking. In Florida the estimated cost of placing tracking devices on all sex offenders is $8 million a year. Conversely it would cost $56 million to keep all offenders securely behind bars (Scarborough Country, 2005). Accounting for each person individually would cost $8 to $12 daily compared to $100 if they were to be kept in prison (Saletan, 2005).

One disadvantage of the parolee tracking process is its labour intensive nature. A Georgian parolee officer who monitors the movements of 17 parolees has said:

> "… the amount of information is overwhelming at times. I could easily spend an hour every morning on each offender to go over the information that's there. For some of them, it's necessary. For some of them, it's not." (Campos, 2005)

4.3.3 Suspected Terrorists

The US and Australia are two western countries that are under threat from terrorist attack and both specify laws which allow police and security agents to use tracking devices. Many national laws confirm the legality of placing a tracking device on

any person suspected of terrorist activity. While the use of terrorism tracking is not documented for security reasons it is still possible to analyse the laws relating to the issue.

The *Australian Security Intelligence Organisation Act 1979* allows for the use of tracking devices on anybody suspected to be involved in "activities prejudicial to security" (ASIO Act, 1979). The Act states that a tracking device may only be used if someone agrees to be tracked or if a warrant is issued. There are two different types of warrants for tracking devices relating to persons and objects. However, both have the same rules.

The Australian terrorism laws have recently undergone a number of changes following an increased terrorist threat and the London bombings of 2005 (Gilmore, 2005). Previously, the maximum period of time a suspected terrorist can be tracked is 6 months (ASIO act, 1979). However, during the Council of Australia Governments (COAG) meeting on counter terrorism it was planned to increase this period to 12 months. (Banham & Wilkinson, 2005).

4.3.4 Employee monitoring

Employees that are tracked using GPS usually travel in vehicles over long distances. Tracked workers include bus drivers, garbage collectors, couriers and truck drivers. It appears that employers want to take away worker freedoms to improve productivity. It is predominantly US companies which use GPS to track their employees.

Automated Waste Disposal Incorporated is one company that uses GPS to ensure their garbage truck drivers do not speed or stray away from their delivery schedule. The company imposed GPS tracking on its employees to reduce overtime and labor costs (Geller, 2005). After implementing the GPS tracking system the workers experienced a drop from an average of 300 hours each in overtime per week to 70 hours (Geller, 2005). The system also alerts employers if a worker spends too much time in one area, whether they are speeding or if they enter an area they are not allowed to be (Geller, 2005).

4.4 Convenience

Tracking people using GPS can also make life easier for individuals and organisations despite its invasiveness. Although GPS tracking may not be widely used for the purposes of convenience, there are a number of commercial uses that can be of benefit to consumers.

4.4.1 Commercial uses

There is an abundance of companies that offer standalone tracking GPS services. Most of these companies are based in the US and offer services to individuals and other businesses.

Satellite Security Systems Inc. (S3) is a San Diego based company that offers vehicle tracking services to a variety of customers including Alzheimer's patients, parents and suspicious spouses (Cha, 2005). Clients carry a GPS device with them which transmits location data to S3 computers to be analysed. S3 tracks so many vehicles that police, state and federal governments and homeland security officials sometimes turn to them for information. (Cha, 2005)

The insurance company Norwich Union uses GPS to track their 18 to 21 year old customers and charges their car insurance premiums based on the time of day they drive. The company induces a tariff at peak times when there is a greater chance of having an accident. Norwich Union also offers 100-miles of free peak benefits per month (Guardian, 2005).

4.5 Conclusion

Analysing each context has given a broad representation of GPS tracking technology and its applications. Companies and individuals are finding innovative ways to use GPS tracking, like insurance companies that use the technology to charge premiums. GPS trackers may not be suited to all its applications, like tracking Alzheimer patients, but can be very beneficial to parents who want to keep track of their children or employers who want to ensure employees are working.

It is also evident that the uses of GPS tracking are blurring – in many cases GPS tracking is being used for multiple purposes. For example, tracking a vehicle can be used to track an employee but can also be used to convict the driver of a crime or give insurance premiums.

5. Observational Study

5.1 Introduction

An observational study was carried out to gain knowledge about the tracking and monitoring process first hand (objective 3). This study involved a participant observer who had his daily movements tracked from Monday 15th August 2005 to Sunday 28th August. The participant observer is a 21 year old male University IT student who works part time and owns a car. Each day during the two weeks of the study the observer carried a Magellan Meridian Gold handheld device either in a carry bag or pant pocket (see image 5.1). The GPS device was setup to collect location data every few seconds. At the end of each day this data was uploaded into GIS software "DiscoverAus Streets & Tracks" which was used to save and analyse data. Throughout the entire study the observer stayed in the area of Wollongong, Australia which is about two hours drive south of Sydney (see image 5.2).

Image 5.1 Carrying the GPS device

Please see print copy for Image 5.2

Image 5.2 The City of Wollongong (Tourism Wollongong, 2005)

A pilot phase was conducted beforehand to investigate any problems that may be experienced during the study (see Appendix 1). The participant observer also made daily journal entries to record the thoughts and feelings he was experiencing (see Appendix 2).

A single participant observational study was used instead of a group study for a number of reasons (table 5.1).

Argument	Explanation
Ethics	It would be difficult to gain ethical consent to track the movements of a group of people and invade their privacy.
Financial	The cost of purchasing numerous GPS devices that would be used only once would not be justifiable.
Time	The time of the study is limited to six months which is not enough time to perform a large study.
Simplicity	The activities of a single participant observer would be much easier than following the movements of a group of people.
Limited scope	As this is an honors thesis the scope of the study is limited to the amount of time and resources available.

Table 5.1 Reasons for participant observation

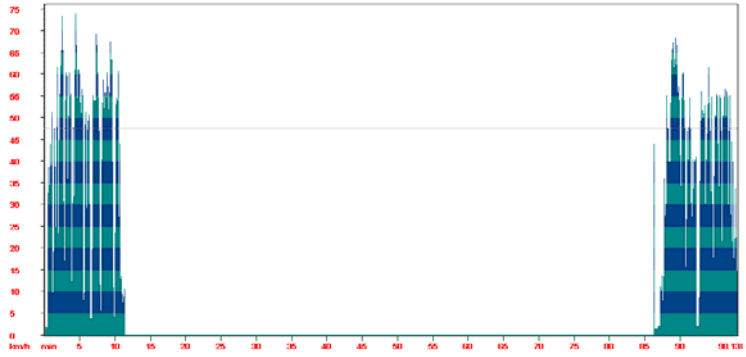
5.2 Track Analysis

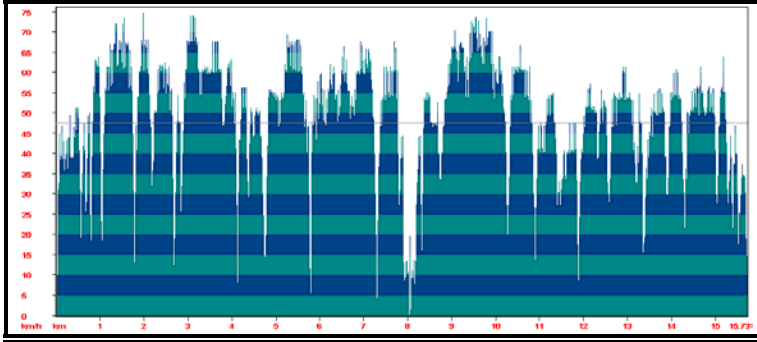
A great deal of information was found out about the observer by tracking him over an extended period of time. From data coordinates it is easy to deduce simple information such as where he is located at a certain time and the speed he is travelling. However, more personal information such as where he lives, his workplace and social activities can also be found. It is also possible to create detailed portfolios about the participant based on his daily travel routines. For instance, the speed he is travelling can indicate the form of transport he is using. How long he spends at a location can determine his activities.

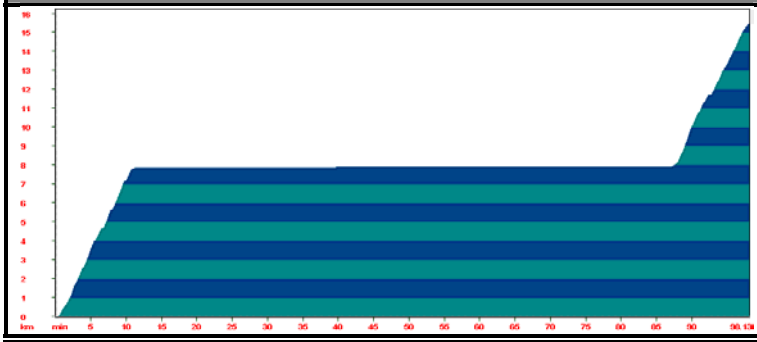
This map shows the participant's movements on day 10 of the study (24th August). On this day he travelled from his home to the University of Wollongong and then to his workplace. This day is typical of other days in the study as the most common locations he travelled to was home, University and work. The user's daily track movements are indicated by the green lines and current location is indicated by the black square. With the GIS software it is possible to play the participant's movements in real time. Roads, highways, train tracks and trails are clearly presented in the map. Key locations, street names and suburb names are also shown.

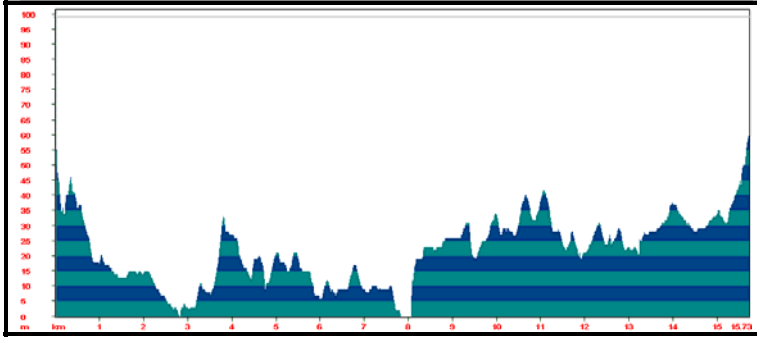
Image 5.3 The participant's movements on day 10

Graphical analysis of track data also gives indications of a person's travel habits and behaviour providing that all the data is accurate and free from errors.

Time/speed	Can determine:
	Speed at a specific time
	When a person is travelling from one place to another
	How long the person spends at a location

Distance/speed	Can determine:
	Speed at a specific point in a journey
	Whether the person is in a vehicle or walking

Time/distance	Can determine:
	The length of time a person stays at a location
	The length of time a person spends travelling
	The number of places a person travels to

Distance/elevation	Can determine:
	A person's location by comparing the elevation patterns with other data

5.3 Issues

5.3.1 Accuracy

Although not perfect the GPS is accurate enough to be perceived as being perfect. However, on several occasions in the observational study substantial errors occurred. Over the two weeks of the observational study there were six significant signal dropouts (see appendix 2 day 5). During a signal dropout a person's location is not known. All of these dropouts occurred while the participant was travelling by car. It is likely that the GPS receiver was not positioned well enough to gain an accurate signal. This kind of signal dropout could be costly in a real life scenario if a person's location was needed (see image 5.4).

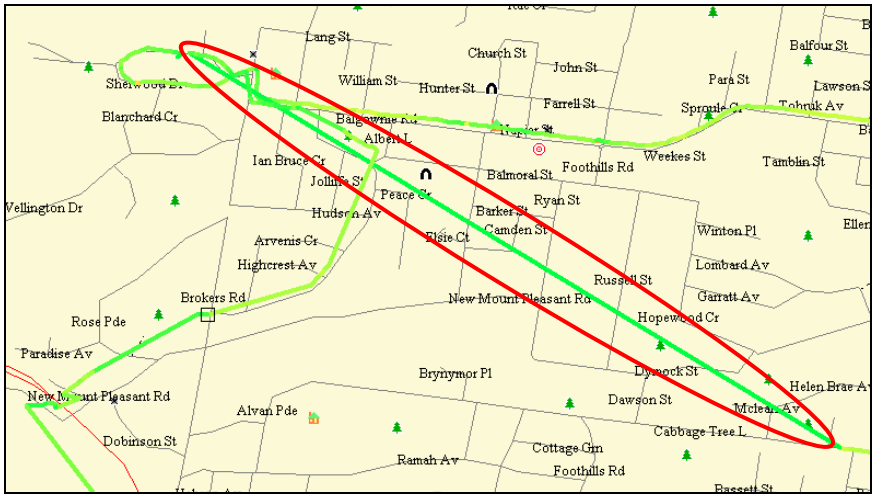
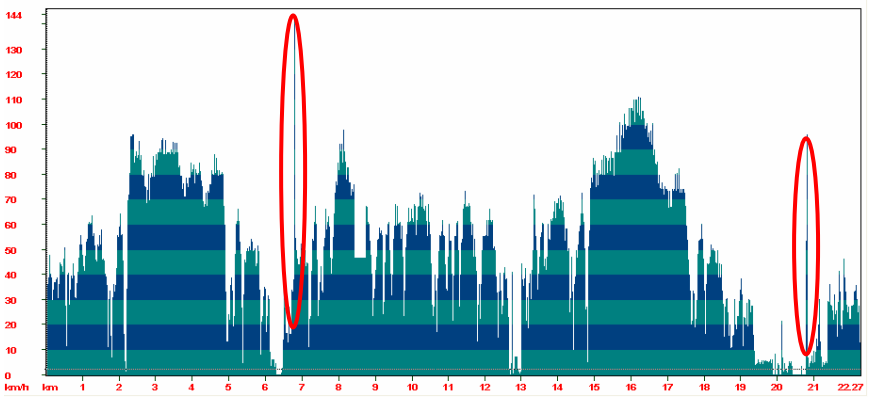


Image 5.4 a signal dropout

There were also five significant speed miscalculations during the study. Speed is found by calculating the difference of distance and time between two points. On day 13 of the observational study the tracking information indicated a speed of 600 km/h whilst in a moving vehicle. This was found by calculating the time and location differences between two subsequent tracking points. The collected GPS data indicated the participant had traveled 0.0479884332997 km in 5 seconds. This calculates to be 600 km/h.

This graph illustrates day 9 of the study when two speed miscalculations occurred (circled in red).



Graph 5.1 Day 9 speed miscalculations

5.3.2 Editing Track Data

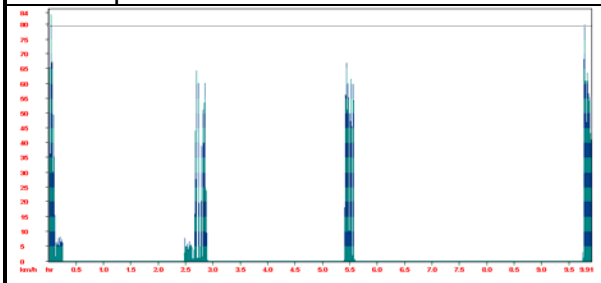
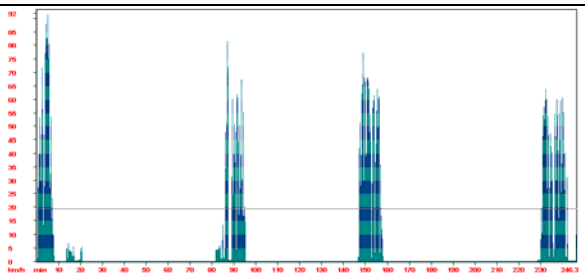
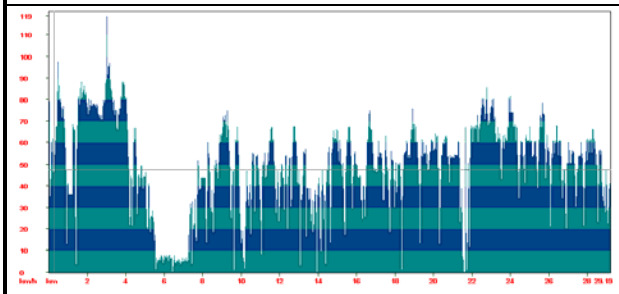
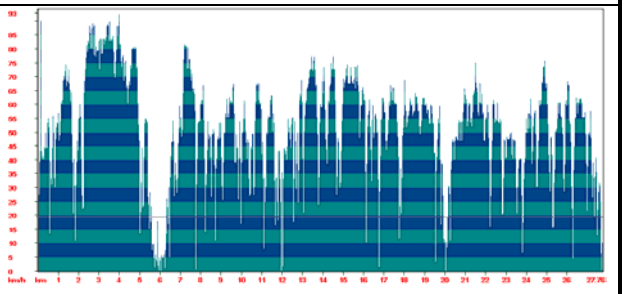
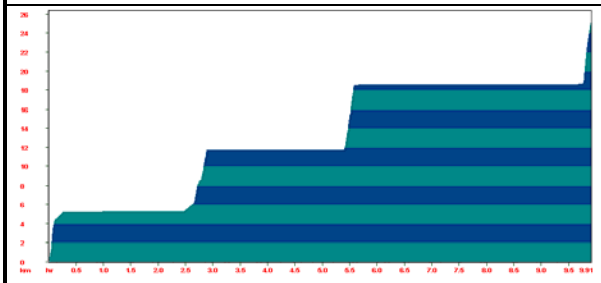
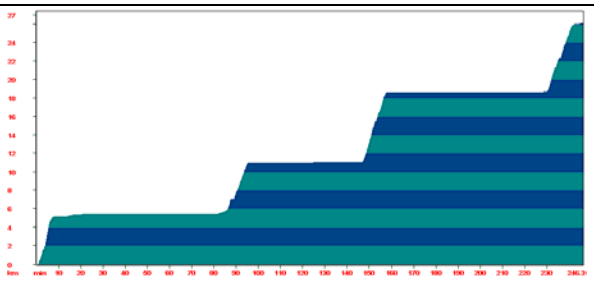
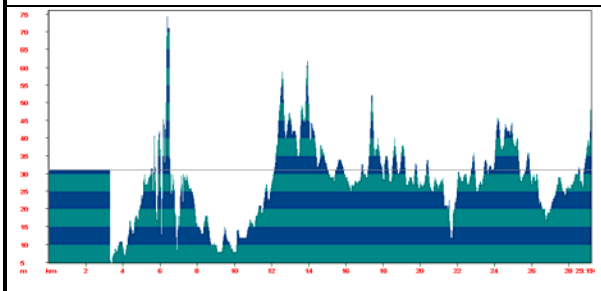
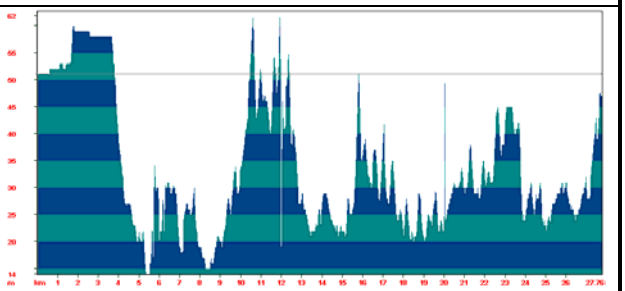
The GPS device used to collect location data stored tracking nodes which store the location and time data every 2-3 seconds. GIS software was then used to create an entire track by joining each tracking node. However, the software also "gives the option to add and edit… tracking nodes" (see appendix 2 day 6). This feature is added to assist in navigation but could be used for other reasons.

The use of GPS location data can be considered legitimate evidence in legal trials (see chapter 4.3.1). It is quite possible to convict an innocent man of a crime he did not commit by editing track data to give a false result. Stringent security and validation checks need to be set in place if police plan to use GPS track data as valid evidence in a court trial.

5.3.3 User Travel Behaviour

An analysis of the track data has shown that the participants' daily movements are quite similar each week and is a reflection of his daily routines and behaviour. The observer took the exact same travel route whenever he traveled to a known location, like home or work, even though there were alternative routes. The track data also reflects the participant's behaviour when he is running late for a meeting (see appendix 2 day 3). This kind of information can be used to create intelligent systems which can observe what a person is doing and then alert if his behaviour is out of the out of the ordinary (see

appendix 2 day 11). Below is a comparison of graphical data from two subsequent Wednesdays:

Day 3: Wednesday 17th August	Day 10: Wednesday 24th August
Time/Speed	
	
Distance/Speed	
	
Time/Distance	
	
Distance/Elevation	
	

Substantial similarities can be seen in each set of graphs. Both sets of time/speed and time/distance graphs indicate the participant traveled on four occasions. The Distance/speed graph shows similar patterns of travelling speed. Additionally, the distance/elevation graphs contain some similarities.

5.3.4 Detail of GIS

The GIS software used provided detail on the roads, highways and the location of some landmarks but did not show any buildings. Little could be deduced from the user's location at certain points because it did not provide enough information on the map (see appendix 2 day 10). The level of detail in a GIS could be made scalable to correspond with its usage. In applications which require high levels of detail the GIS could be setup to display roads, buildings and landmarks. Conversely, if little detail is needed it could show the user's location in relation to important landmarks.

5.3.5 User Awareness

Several days into the study the user indicated that it was easy to forget about being tracked (see Appendix 2 day 8). Any activity that is carried out at length could easily become routine. By the end of the study the user was not worried about being tracked but was more concerned about having to carry the device around (see Appendix 2 day 13). If GPS were to be used as a deterrent it may lose its effectiveness over long periods of time.

5.4 Conclusion

This participant observation study has given a practical perspective to the process of GPS tracking and proven that it can be accomplished with relative ease. It is obvious that tracking a person over an extended period is an invasion of privacy as it tracks every detail of a person's movements. The probability of inaccuracies and the possibility of editing data poses a question about the reliability of such information in criminal cases. The effectiveness of GPS tracking in deterring crime may not be as great as first thought because the user may become blasé about its presence.

6. Discussion

6.1 Framework for Ethical Issues

A framework has been devised to analyse the ethical issues of GPS tracking and monitoring. This framework is based on the IT ethical issues framework created by Mason (1986) and Mason et. al. (1995) and updated by Turban (2002). Ethical issues are categorised into privacy, accuracy, property and accessibility.

- Privacy: collection, storage and dissemination of information about individuals.
- Accuracy: authenticity, fidelity and accuracy of information collected and processed.
- Property: ownership and value of information and intellectual property.
- Accessibility: right to access information and payment of fees to access it.

Some questions have been changed or removed to make the framework more relevant to the ethics of GPS tracking and monitoring.

Privacy	Accuracy
• What location specific information should an individual be required to reveal to others? • What kind of surveillance can a parent use on a child? • What kind of surveillance can employers use on employees? • Do police need a warrant to track a suspected criminal?	• Who is responsible for the authenticity, fidelity and accuracy of information collected? • Who is to be held accountable for errors in information, and how is the injured part compensated? • Is GPS an appropriate tracking technology for dementia wandering? • How can we ensure that errors in databases, data transmissions and data processing are accidental and not intentional?
Property	**Accessibility**
• Who owns the information? • What are the just and fair prices for the exchange?	• Who is allowed to access the GPS service? • How much should be charged for permitting accessibility to information? • Who will be provided with equipment needed for accessing information? • Is the tracking of parolees and sex offenders justified?

Table 6.1 Ethical framework

6.2 Ethical Discussion

6.2.1 Privacy

The greatest concern of GPS tracking is the amount of information that can be deduced from the analysis of a person's movements. It is quite possible that a person's right to privacy may be compromised over the benefits that GPS tracking can provide.

What location specific information should an individual be required to reveal to others?

In many cases a person's location does not need to be known unless he/she does something wrong. Parents only need to know if their child is not home or speeding. Caregivers should only by notified if a dementia patient is wandering. Parole officers only need to know if a parolee enters a restricted area. Employees should only be notified if a worker is not carrying out instructions. If reliable automated systems can be setup to notify trackers that they are breaking a rule it will forgo the need for constant tracking which is invasive (chapter 5.3.3). The level of detail in GIS could also be controlled to restrict the amount of information available (chapter 5.3.4).

People should always be informed of the ramifications of being tracked. The ASIO Act states that the Australian government can lawfully track a person that consents (chapter 4.3.3). It is ethical for the person being tracked to be given clear information about the consequences.

What kind of surveillance can a parent use on a child?

Using GPS tracking a child's location can be found at anytime (chapter 4.2.2). If a child is lost or kidnapped s/he has a good chance of being found quickly. They may be prevented from getting involved in dangerous activities. But does the child have a say in this and should his/her independence be taken away? Are parents replacing trust with technology? (Yeebo, 2005) Christy Buchanan, an associate professor of psychology makes a contemplative point:

> "Parents shouldn't fool themselves into thinking that they can keep their kids from making mistakes, which is a part of growing up and learning." (Anonymous, 2005)

On the other hand parents who have experienced the loss of a child see GPS as a life saving technology. This is especially true for the parents of teenagers who have just received their driver's licence. Jack Church, vice president of marketing at Teen Arrive Alive in Bradenton, Fla., lost his son in a drink-driving accident. He advocates that tracking children is not about spying but about safety (Yeebo, 2005).

What kind of surveillance can employers use on employees?

Employers are usually tracked to save company money by reducing overtime of workers (chapter 4.3.4). Again it is an ethical dilemma. Whose rights are paramount? The employer who protects his business and profits or the employee who has a right to privacy. Galen Monroe, a truck driver from Chicago USA, voices his concern:

> "These systems could be used to unfairly discipline drivers, for counting every minute that they might or might not be on or off duty and holding that against them" (Geller, 2005)

Managers on the other hand are more concerned that workers are doing what they are paid to do. Safeguards need to be set out to ensure employees are not tracked when they are on a break or finished work.

Do police need a warrant to track a suspected criminal or terrorist?

Several cases have ruled that tracking a person with a GPS device is the same as following them on a street (chapter 4.2.1). However, GPS tracking is much more pervasive. Firstly, a person will be more aware of a person following them than a small tracking device attached to their vehicle. Additionally, a GPS tracker can find a person's location anywhere at anytime even when trailing is not possible. Furthermore, since a tracked person's location is digitised it can be instantly analysed in ways that simple observation cannot.

If the issuing of warrants is not compulsory there will be no barriers for police or security personnel to place track devices people. Warrants are essential to ensure GPS tracking devices are used justly and ethically.

6.2.2 Accuracy

The GPS system is fraught with accuracy issues and professionals are always reminding users of the technology's inaccuracies. Small errors can be caused by tree canopies, tall buildings and cloud cover but are negligible compared to the potential inaccuracies that can occur when the location information is processed as evidenced by the participant observation (chapter 5.3.1).

Who is responsible for the authenticity, fidelity and accuracy of information collected?

Many people rely on the GPS system so if the system fails it is possible that many companies can lose business and people can get hurt. So who is responsible for accuracy? The US government created the system but is it their obligation to ensure accuracy for users?

The US government has the right to prevent access to GPS and have even released plans to shut down parts of the network in a "national crisis" to prevent terrorists from using the network (Bridis, 2004). If there was some kind of threat to security or a satellite failure many people who rely on the system could be inconvenienced.

Another concern is that 16 of the 28 GPS satellites currently in orbit are beyond their design life and are likely to fail in the near future (Bingley, 2005). At least two satellites are failing each year and launches of new satellites are barely keeping up (Bingley, 2005). This poses problems for the users of the GPS system.

Who is to be held accountable for errors in information, and how is the injured part compensated?

Private companies who offer GPS tracking services avoid liability by introducing product descriptions, warranties and disclaimers (Sovocool, 2000). One case demonstrates the problem when errors occur in the GPS. In California several rental car companies were wrongly fining customers for breaking their rental agreement by leaving the state (Cha, 2005). Customers were asked to pay $3000 for something they did not do. As a result California became the first US state to outlaw the use of GPS receivers by car

rental companies to track their customers. Even though these errors were not the fault of the company the rental car industry still had to give up the GPS technology.

Is GPS an appropriate tracking technology for dementia wandering?

The Project Life Saver Organisation is a non-profit organisation that helps locate and return wandering dementia sufferers (Project Life Saver, 2005). They believe that GPS is not suitable for tracking dementia sufferers and identify three important factors of a wandering dementia sufferer:

1. A wandering dementia sufferer is a critical emergency
2. The person is unaware of the situation
3. If the person is not found within 24 hours, there is a nearly 50% chance they will die. (Saunders, 2005)

They also recognise that GPS lacks the four fundamental attributes of an assistive technology: reliability, responsiveness, practicality and affordability (Saunders, 2005).

How can we ensure that errors in databases, data transmissions and data processing are accidental and not intentional?

The software used to store tracking data throughout the observational study made it possible to edit the data points (chapter 5.3.2). Track data could be edited to create false evidence. Effectively a person can be framed for a crime or activity s/he did not commit. For this reason it is imperative that strenuous validation checks are enforced to ensure data is not purposefully altered. This is especially important for companies who offer GPS tracking as a service.

There is also a concern with the intentional and non intentional jamming of GPS signals. GPS receivers are incredibly sensitive and are susceptible to jamming. There have even been cases of unintentional jamming (Wikipedia, 2005). There are anti-jamming techniques but they are not widely available. Safeguards and laws restricting GPS jamming need to be advocated.

6.2.3 Property

Who owns the information?

The US government owns the physical satellite system but who owns the information once it is collected? If a company collects location information on a person who commits a crime are they obligated to hand it over to the police? It is possible that this could lead to further crimes like blackmail.

What are the just and fair prices for the exchange?

Currently it is free to use the GPS as long as you have a receiver. George Bush claims that selective availability will never be reinstated (Bridis, 2004). It is important to keep in mind that free service is not for commercial satisfaction but for the benefit of transport, aviation and science industries.

6.2.4 Accessibility

Who is allowed to use the GPS service?

One of the objectives set out by GPS policy is to provide:

> "worldwide basis civil space-based, positioning, navigation, and timing services" (OSTP, 2004).

However, GPS policy also indicates that the GPS system can be shut down in certain areas "under only the most remarkable circumstances" like in the event of a terrorist attack (spacetoday.com, 2004). George Bush has made it clear that any enemies of the United States should not be able to use the technology (Bridis, 2004). It appears that only allies of the United States are allowed to use the GPS service.

How much should be charged for permitting accessibility to information?

US policy proclaims that the GPS service is and will continue to be "free of direct user fees" (OSTP, 2004). However private companies are billing customers to use this service. Costs may include payment for equipment and data transmission but there is the possibility of hidden fees.

Who will be provided with equipment needed for accessing information?

Parolee tracking is more cost effective than detainment but it is impossible to have all parolees and sex offenders tracked (chapter 4.3.2). So who will be tracked and who will not? In previous cases less aggressive criminals are are placed with GPS tracking devices first (Saletan, 2005). Previous radio tag tracking methods have required parolees to pay for their own tracking devices (Saletan, 2005). If all parolees and sex offenders cannot be tracked this could be a possible solution.

Is the tracking of parolees and sex offenders justified?

Why are parolees and sex offenders tracked in the first place? The four most apparent reasons appear to be to save revenue, deter further crimes and for controlled rehabilitation. The cost of tracking a person is much lower than incarceration (chapter 4.3.2). However, allowing previously convicted felons to roam the streets with the knowledge that they may offend again is unethical. Tracking may deter some criminals from acting out but if they are tracked at length they may lose awareness of their GPS device (chapter 5.3.5).

The rehabilitation of criminals is very stressful and detrimental to those involved. A professional believes that tracking parolees helps a parolee by giving the opportunity to spend time with family and loved ones.

6.3 Further Discussion

Some services can be misused. Teen Arrive Alive can easily be used to track other individuals. Just give them a Nextel phone, sign up to the service and you have instant blame-free tracking.

If the technology can save a human life is it unethical to use it? There are many scenarios where this could happen. A parent stops their teenage son from speeding and saves him from a fatal crash. A parole officer is alerted to a pedophile entering a primary school. A suspected terrorist is tracked and is found to be planning an attack in Australia.

6.4 Conclusion

GPS tracking is a double edged sword. It has many positive and negative ramifications. It can potentially save lives but at the expense of a person's right to privacy. Reasons for the ethical and unethical aspects of various GPS tracking applications are given in table 6.2. There is also a definite lack of responsibility for GPS services. When selective availability was introduced the US government gave private companies the opportunity to increase their profits. However, this has caused problems as none of the parties involved accept responsibility for GPS inaccuracies.

Application	Reasons for being ethical	Reasons for being unethical
Tracking dementia wandering	• Wandering patients are able to be located before they are harmed. • Provides a sense of security to caregivers.	• Technology may not be suited to dementia wanderers as it can be unreliable, unresponsive, impractical and unaffordable.
Parents tracking children	• Children can be located if they are lost or abducted. • Can prevent children from speeding or disobeying instructions.	• Invasion of child's privacy. • The child may not have a choice.
Police placing tracking devices on suspected criminals	• GPS evidence may be used to rightly convict a person of a crime.	• May be used without a warrant. • Location data may be modified to create a false alibi or false accusation.
Tracking parolees and sex offenders	• May prevent crimes from occurring. • Controls and rehabilitates parolees and sex offenders.	• It could impose restrictions on parolees who are not likely to offend again.
Employers tracking employees	• Business owners can increase profits by ensuring employees are working efficiently. • Encourages workers to be honest.	• Employees may still be tracked outside of work hours and the information used against them. • May be used to unfairly discipline drivers.
Shutting down parts of the GPS	• May thwart terrorist attempts.	• Many businesses and individuals may be inconvenienced.

Table 6.2 Ethics involved in GPS tracking applications

7. Conclusion

The growing popularity of GPS tracking means that the ethics of GPS tracking will continue to be of concern in the future. This study has used the methods of usability context analysis and an observational study to create an ethical discussion on GPS tracking. Several major implications have arisen from these studies which are relevant to the people who impose tracking on others. There is the possibility for further research to be undertaken.

7.1 Major Implications

The usability context analysis focused on the context of care, control and convenience. However, it is apparent that many GPS tracking uses are based on convenience, not care or control (as proposed by Amy Masters, 2003). GPS tracking is not utilised for the sole purpose of controlling the lives of others, a person being tracked does not experience any *immediate* consequence if they do something wrong. Similarly, a caregiver can look after a person even without a tracker. Instead, GPS tracking makes life much easier for those who use it. For example, governments use GPS trackers on parolees and sex offenders to reduce the cost of detainment. Employers track their workers to maximise profit by ensuring they are working. Parents track their kids because they are too busy to watch their children 24/7. Additionally, tracking dementia sufferers is essential because the number of aged carers is too few and the need is too great.

Some cases of GPS tracking allow it to used for the wrong reasons or misused by some individuals and groups. Some of its current uses are not justified like the need to track parolee to save revenue. GPS trackers may also be ineffective as a deterrent if used on parolees and sex offenders. Additionally, placing GPS trackers on suspected criminals without a warrant is neither constitutional nor ethical. Safeguards must also be set in place to ensure that GPS location data is not modified to create a false alibi or accusation.

Tracking is very invasive so care must be taken to ensure that only essential information about that person is revealed. Levels of privacy can be controlled by incorporating intelligent systems and customising the amount of detail in GIS's. If these types of measures are enforced GPS tracking can be used in an ethical manner which is beneficial to the person being tracked, not detrimental.

GPS is an effective technology and it can potentially save lives, however many current applications are not suited to it. Many groups of people rely heavily on the technology even though it is prone to inaccuracies and unreliable at times. Technological convergence may correct some of these issues but a real problem is posed if GPS is used on its own. The US government is even allowed to shut down parts of the system in times of crisis and is also having trouble maintaining satellites. When using any form of GPS tracking device backup systems need to be implemented and a Murphy's Law type mentality needs to be encouraged: "If the GPS can fail, it will fail!"

7.2 Who Do the Findings Apply To?

These findings apply to all parties which track the movements of others as mentioned in the usability context analysis. These groups include police responsible for law enforcement, parole officers, carers of dementia patients, parents who want to track their children and employers who track their employees. These groups need to ensure that the tracking of people is done in a just and ethical fashion. It is up to the trackers to ensure that the tracking of another human is done in a way which is beneficial to the person involved and the wider community.

7.3 Further Research

The next step in this line of research would be to carry out a group observational study. The observational study in this paper was limited to a single participant but it would be interesting to track the movements of a group of people. A study like this could be used to investigate whether detailed portfolios can be created from anonymous participants based on their travel patterns. Another aim could be to create an intelligent system that would collect and analyse the movements of people automatically. In addition to an observational study several people who have had GPS tracking imposed on them could be interviewed to ascertain the emotional and psychological consequences of having a GPS tracking device attached.

Appendices

Appendix 1: Pilot Study

A two day pilot study was conducted before the actual observational study to iron out any glitches in the workings of the study.

- Daily activities – at the start of each day the device will be turned on as soon as the participant leaves the house. At the end of each day the device will be switched off.
- Carrying the GPS device – the device will be carried in the user bag or pocket whilst walking. When driving, the device will be placed securely in a dock.
- Tracking node limitation – the device is only capable of collecting 2000 tracking nodes at a time. While this is more than enough for a single day of tracking it is not enough for more than one day. Care must be taken to ensure that track data is erased at the end of each day so there will be enough memory for the next day.
- Getting a signal – it takes about a minute to gain a signal so when the device is first turned on the user will have to wait until a signal is made.
- Indoors – the device looses its signal when indoors so when the signal is lost at a certain location it will be assumed that the user is indoors.
- Battery life – the manual indicates that the device can get up to 14 hours of usage on two AA batteries. Rechargeable batteries do not have enough power to keep the GPS device running throughout an entire day. Non-rechargeable batteries will be replaced when they are running low.

Appendix 2: Observational Study Diary

Diary entries were made at the end of each day from Monday 15th August to Sunday 28th August.

Day 1: Monday 15th August 2005

Today was the first day of tracking. Throughout the day I was very conscious of the device I was carrying. Every time I left for a new location I would check if the device was working and if I was getting an accurate reading. A person being tracked would not be too concerned whether their receiver was working or not. Although a parolee with a faulty tracking device may face some penalty.

Day 2: Tuesday 16th August 2005

It would seem that my primary objective is to simply carry the device, not to track my movements. I rarely think what someone would think. In fact, I am in a different state of mind when I am downloading and looking over the waypoints I collected that particular day. Most of the time when I am travelling from place to place I am concerned about whether the device is working, how much battery life I have left, if a signal has been picked up.

Day 3: Wednesday 17th August 2005

Running late for a meeting today I noticed that I was travelling faster than normal. Not just when I was driving but my walking pace was very fast. This behaviour was projected through my physical movements which were picked up in the GPS receiver. From this experience it could be possible to create user profiles on a person being tracked. For example, analysing the walking speed can reveal an approximate walking span and from that the approximate height of the person can be deduced. This idea may seem farfetched and outlandish but it is very interesting to see if it could be done.

Day 4: Thursday 18th August 2005

A thought occurred to me while I was driving to the RTA to do my driving test for my full licence. What if all cars carried a GPS or similar LBS device on board and two cars were involved in a car accident. The *Driver Qualification Handbook* indicates that three

most common types of crashes by new drivers involve two cars in rear-end collisions, adjacent collision when turning corners and opposite collisions when turning corners. A GPS could be used to reveal what exactly happened in an accident like which person hit first and which person was travelling the fastest. If cars *were* being tracked there could be rules set out to provide automated emergency responses. For example, if the speed of a vehicle decelerated at an alarming rate, i.e., from 100 km/h to 0 km/h in less than a second, it would be fair to say that the vehicle was involved in an accident.

Day 5: Friday 19th August 2005

While analysing today's tracking data I have noticed that the device sometimes loses a signal when I am driving. This is most likely due to the poor placement of the receiver. If a GPS device was used to track a person the placement of the receiver will be very important. Parolees often have GPS devices placed around their ankles leaving it very low on the body and unable to get the best signal. I think receivers need to be placed higher up on the body to ensure continuous and accurate readings.

Day 6: Saturday 20th August 2005

The mapping software I used to download my tracking data gives the option to add and edit way points or tracking nodes. It would be easy to frame a person by editing the location data and disproving any alibi they may have. How reliable is location data collected from GPS devices alone?

Day 7: Sunday 21st August 2005

After a week of tracking I have decided to extend the period of personal tracking so that I will have more data to analyse. I am not concerned about tracking my movements for another week. In fact, I am eager to continue this study to get more data.

Day 8: Monday 22nd August 2005

Starting the second week of tracking today and my awareness of the tracking of my own movements has dulled. Throughout the day I do not consciously think of myself being tracked. At times I may check if the device is working correctly but I am not concerned

about the data the device is collecting about me. I can easily say that, after eight days of tracking, I am used to the process even though it is such an abnormal activity.

Day 9: Tuesday 23rd August 2005

After replacing the batteries in the device with a fresh set I have noticed the device picks up a signal much quicker than it does with a used set of batteries. This makes sense to me; the more power the device has the better it will work. However, this has ramifications for people being tracked, especially prisoners on parole who have to recharge the batteries each day.

Day 10: Wednesday 24th August 2005

It has occurred to me that the pervasiveness of GPS tracking depends on the complexity and detail of the GIS being used. The more information being displayed on a GIS such as landmarks, roads, side streets the more information about the person's location. When I analyse my own movements at the end of the day I have to remember where exactly I was and why I went there.

Day 11: Thursday 25th August 2005

I have noticed that so far my data is fairly static based on my weekly and daily routines. For example, I regularly travel to University and my workplace at the same time and day each week. I can assume that many people have daily routines including people that are tracked with GPS. Intelligent systems could be developed to monitor these movements automatically. The system could analyse a person's movements over a week or two and develop an information system that would develop a user profile based on their activities.

Day 12: Friday 26th August 2005

No entry.

Day 13: Saturday 27th August 2005

The entire process of tracking my movements has become a habit. I can imagine it would be similar for any person who has to have their movements tracked. I am relieved the entire process is drawing to a close mainly because I do not have to carry around the GPS device anymore. This is not on account of the bulkiness or weight of the device (it only

weighs 233 grams). My relief comes from the knowledge that I do not have to worry about being attached to this gadget both physically and mentally.

Day 14: Sunday 28th August 2005

Today is the final day of this study. I did not track my movements today because I stayed at home. Looking back at the previous weeks I did make an effort to travel a lot so I would have a substantial amount of data to analyse. I wonder if this will have an opposite effect on a person being tracked by a second party. Would they travel less? Would a teenager being tracked by his/her parents still go a rave party or are they more likely to stay home? Would a convicted pedophile stay home to avoid temptation?

Summary of Movements

Day 1. home > uni > home > uni >*signal dropout*

Day 2. home > uni > home (speed miscalculation)

Day 3. home > uni > home > work > home

Day 4. home > rta >*signal dropout*> home > *signal dropout* > uni > masterbuilders > unibar > home

Day 5. home > uni (speed miscalculation) > *signal dropout* > home

Day 6. home > petrol station > *signal dropout* > work

Day 7. work > home > work > home

Day 8. home > work > home

Day 9. home > uni (speed miscalculation) > woolworths > *signal dropout* > home (speed miscalculation) > work(gym) > home

Day 10. home > uni > home > work(gym) > home

Day 11. home > work

Day 12. home > work (gym) > home > work

Day 13. work > home > work (bbc) > home (speed miscalculation)

Appendix 3: Glossary

All definitions taken from www.wikipedia.org except when indicated otherwise.

AGPS – AGPS or Assisted GPS is a variant of GPS used in cell phones. It uses an assistance server to cut down the time needed to find the location.

DGPS – Differential Global Positioning System (DGPS) is an enhancement Global Positioning System that uses a network of fixed ground based reference stations to broadcast the difference between the positions indicated by the satellite systems and the known fixed positions.

GALILEO – The Galileo positioning system is a proposed satellite navigation system, to be built by the European Union as an alternative to the military controlled US Global Positioning System and the Russian GLONASS. The system should be operational by 2008.

GIS – A geographic information system (GIS) is a system for managing spatial data and associated attributes. In a more generic sense, GIS is a "smart map" tool that allow users to create interactive queries (user created searches), analyse the spatial information, and edit data.

GPS – The Global Positioning System, usually called GPS (the US military refers to it as NAVSTAR GPS), is a satellite navigation system used for determining one's precise location and providing a highly accurate time reference almost anywhere on Earth or in Earth orbit. It uses an intermediate circular orbit (ICO) satellite constellation of at least 24 satellites.

GSM – The Global System for Mobile Communications (GSM) is the most popular standard for mobile phones in the world. GSM phones are used by over a billion people across more than 200 countries.

LBS – A location-based service (or LBS) in a cellular telephone network is a service provided to the subscriber based on her current geographic location. This position can be known by user entry or a GPS receiver that she carries with her, but most often the term implies the use of a radiolocation function built into the cell network or handset that uses triangulation between the known geographic coordinates of the base stations through which the communication takes place.

PDA – Personal digital assistants (PDAs or palmtops) are handheld devices that were originally designed as personal organizers, but became much more versatile over the years. A basic PDA usually includes a clock, date book, address book, task list, memo pad and a simple calculator.

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