THE IMPACT OF GLOBAL POSITIONING SYSTEMS (G.P.S.) IN LAND SURVEYING AND THE RELATED COMPETENCIES NEEDED BY LAND SURVEYING GRADUATES IN THE STATE OF WISCONSIN

by

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ABSTRACT

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THE IMPACT OF GLOBAL POSITIONING SYSTEMS (G.P.S.) IN LAND
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SURVEYING GRADUATES IN THE STATE OF WISCONSIN

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This descriptive study examines the impact that Global Positioning Systems (G.P.S.) has had on the land surveying industry. The study seeks to determine specific information on G.P.S. skills, knowledge, and equipment presently being used in the land surveying industry. The curriculum from institutions in Wisconsin that offer surveying programs will be presented. The study will also examine surveyors' attitudes toward using G.P.S. along with competencies required of land surveying graduates who will be using this technology. Differences in competencies needed or equipment used based on the size of the company will also be explored.

The study involved 145 land surveying companies in the state of Wisconsin who received a questionnaire. The results from the companies who completed and returned the questionnaire is presented along with a summary of the data, conclusions, and recommendations for further study.

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Acknowledgements

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Chapter 1

INTRODUCTION

The profession of land surveying has played significant roles throughout the history of the United States. Lewis and Clark were surveyors who helped to survey the Louisiana Purchase. Charles Mason and Jeremiah Dixon were two surveyors who established the boundary between Pennsylvania and Maryland that we know today as the "Mason - Dixon Line" (Pynchon, 1997). Other famous surveyors include George Washington and Thomas Jefferson.

The history of surveying is as old as recorded civilization. The *Old Testament* even refers to property corners. For example, Proverbs 23:28 "Remove not the ancient landmark, which thy fathers have set." In 1400 B.C. Egypt was surveyed and divided into plots for taxation purposes (McCormac, 1976; McEntyre, 1978; Wolf & Brinker, 1994). During the eighteenth and nineteenth centuries, surveying progressed more rapidly. Both England and France were accurately surveyed to produce maps which delineated their national boundaries (Wolf & Brinker, 1994). In 1785, the United States introduced the Public Land Survey System which was an attempt to systematize land subdivision. Land would be divided into 6 mile square tracts called townships. Townships were later divided into 36 sections which were 1 mile square. This system later came to be known as the rectangular system of subdividing public lands (McEntyre, 1978; Onsrud, 1979).

With increasing land values and the need for precise boundaries during the canal, turnpike, and railroad eras, surveying took an even more prominent position. Today surveying is needed for construction, land subdivisions, engineering, and exploration. It also plays a significant role in our nation's defense. Recent wars such as Operation Desert Storm required a need for precise measurements and accurate maps (Wolf & Brinker, 1994).

The need for increased precision in surveying has led to improved technology. Surveyors in the 1800's used a compass for determining directions and a steel chain for measuring distances. Over time devices such as transits, theodolites, and total stations have been developed which essentially save time and increase accuracy. In addition to this technology, during the 1970's the United States government was also developing technology that would have significant implications in the field of land surveying.

G.P.S. (Global Positioning Systems) was initially developed by the Department of Defense for use in the military (French, 1996; Van Sickle, 1996).

The U.S. Department of Defense began work on (NAVSTAR) Navigation Satellite Time and Ranging in 1973. The $12 billion project took 20 years to complete. The goal was to provide military ships, aircraft, and ground vehicles with the ability to determine their precise location anywhere in the world (Nord & Jabon, 1997).

Today land surveyors are making the most of this new technology. Surveyors have used G.P.S. because it can measure latitude, longitude, and altitude with amazing speed and accuracy (Fralinger & Maxwell, 1997; Keating, 1999; Monro, 1998; Mooney, 1998; Van Sickle, 1996).

Land surveying is currently being revolutionized in the way that data is measured, recorded, processed, stored, and retrieved. A large part of this has to do with the development of satellite and computer technology. G.P.S. has been used in almost every type of survey including control work, property surveying, topographic mapping and construction staking. G.P.S. equipment does cost considerably more than traditional surveying equipment, however, the advantages it provides makes it very cost - effective. The cost of G.P.S. has steadily decreased over the years and will soon be affordable to all surveyors. The advantages of G.P.S. include speed, accuracy, and the ability to function either day or night and in any type of weather (Wolf & Brinker, 1994). Also, because G.P.S. uses satellite signals for positioning, intervisibility between points is no longer needed (Anderson, 1999; Estlick, 1998; Wolf & Brinker, 1994).

The state of Wisconsin, like many other states has required the services of professional land surveyors. Today with the decline in Wisconsin's family farms, land is being sold and subdivided at an astonishing rate. One only needs to drive down the highway to realize how much development is taking place. Professional surveyors in the state of Wisconsin, like most other states, are required to be licensed. As of July 1, 2000, Wisconsin will be changing its licensing requirements for becoming a land surveyor. According to the Wisconsin Department of Regulation and Licensing, candidates will be required to possess either a two or four year degree in land surveying, combined with additional work experience in land surveying to total six years. Candidates, who do not possess a degree, may also become registered by acquiring at least 10 years of land surveying practice. After meeting one of the above requirements, an applicant must take and pass both a national exam as well as an examination on surveying practice in Wisconsin. Although a few surveyors choose to learn everything on the job, the majority of them obtain some type of formal education. Wisconsin has numerous institutions that offer programs in land surveying.

The purpose of these programs is to provide students with the necessary skills and knowledge needed to function in the workforce. With the change in surveying technology one needs to ask if Wisconsin’s educational institutions are updating their curriculum to keep up with these changes. How important is G.P.S., and what do surveying graduates need to know about using it? With increases in technology, society will continue to demand higher standards. According to (Wolf & Brinker, 1994), “Consequently in a few years the demands on surveyors will be very different from what they are now.”

Statement of the Problem

Many professional land surveyors in the State of Wisconsin have recently invested in G.P.S. technology. This technology is fairly new to surveyors as well as to graduates of land surveying programs across the state. Most surveying programs expose students to different aspects of G.P.S., however, a study has never been done to determine professional’s perceptions of what graduates should know about G.P.S. to be employed. Land surveying graduates may not have adequate knowledge and training about G.P.S. to meet the needs of surveying firms. A guide is needed to determine how much knowledge of G.P.S. graduates should have to be successful in today’s workforce.

Purpose of the Study

The purpose of this study is to determine specific information on G.P.S. skills, knowledge, and equipment presently being used in the land surveying industry as measured by the responses to a survey questionnaire. Some surveyors are using G.P.S. and some are not. Surveying graduates will more than likely be using G.P.S. sometime in their careers. A prior study to determine competencies of surveying graduates was done by (Van Goethem, 1992), but this study did not focus solely on G.P.S. competencies.

Objectives

This study sought answers to the following:

1.) How widely used is G.P.S. by Wisconsin surveying firms?

2.) Is there a relationship between using G.P.S. and company size?

3.) What competencies related to G.P.S. should graduates be able to perform on the job?

4.) What are surveyor’s perceptions of student preparedness regarding G.P.S. competencies?

5.) What subject areas related to G.P.S. do surveyors feel are the most important for entry-level employees to know?

6.) What are surveyor's perceptions of student preparedness in subject areas related to G.P.S.?

Significance of the Problem

1.) Wisconsin and other states with surveying programs might find this information useful. They could use the results to update their curriculum.

2.) Professional organizations would benefit from the data as they develop and revise licensure requirements.

3.) The information could be used to benchmark the state of Wisconsin with other states.

Limitations

1.) The instrument used was developed by the researcher. While every effort was made to validate the instrument, norm referenced validation was not used.

2.) The respondents to the questionnaire may have different amounts of knowledge and work experience.

3.) The respondents may also have different amounts of education. Some surveyors possess college degrees while others have degrees from technical colleges.

4.) G.P.S. equipment may only be available to companies committed to it.

Definition of Terms

Automatic level - "A leveling instrument in which the line of sight is automatically maintained horizontal by means of a built-in pendulum device" (Definitions of Surveying and Associated Terms, 1978, p.91).

Base station - "Also called a reference station. A receiver that is set up on a known location specifically to collect data for differentially correcting rover files. The base station calculates the error for each satellite and, through differential correction, improves the accuracy of G.P.S. positions collected at unknown locations by a roving G.P.S. receiver" (http://www.cgrer.uiowa.edu/cgrer_lab/gps/).

Chain - "A unit of length used in the subdivision of public lands of the United States. The Gunter's chain is 66 feet long and is divided into 100 links each 7.92 inches long" (Definitions of Surveying and Associated Terms, 1978, p.27-28).

Compass - "An instrument used in determining the azimuth or direction of a body relative to the meridian of a place" (Definitions of Surveying and Associated Terms, 1978, p.33).

Data collector - "An electronic field book, connected to a theodolite or total station where distance and angle measurements are recorded automatically at the time of the measurement" (Van Goethem, 1992, p.10).

Differential G.P.S. - "A system that uses radios signals broadcast from ground stations to substantially improve the positioning accuracy of G.P.S., and overcome the effects of selective availability" (Ferguson, 1997, p.242).

Electronic distance-measurement (E.D.M.) - "Measurements made with devices that compare the phase difference between transmitted and returned (i.e., reflected or retransmitted) electromagnetic waves, of known frequency and speed, or the round-trip transit time of a pulsed signal, from which distance is computed" (Definitions of Surveying and Associated Terms, 1978, p.59).

Ephemeris - "A publication giving coordinates of celestial bodies at uniform time intervals; the coordinates are usually given for one calendar year" (Definitions of Surveying and Associated Terms, 1978, p.61).

Geodesy - "The science which treats mathematically of the figure and size of the earth. The term is often used to include both the science, which must depend on determinations of the figure and size of the earth from direct measurements made on its surface (triangulation, leveling, astronomic, and gravity determinations), and the art, which utilizes the scientific determinations in a practical way and is usually known as geodetic surveying or geodetic engineering" (Definitions of Surveying and Associated Terms, 1978, p.73-74).

Geodetic survey - "A survey in which account is taken of the figure and size of the earth. Geodetic surveys are usually prescribed where the areas or distances involved are so great that the results of desired accuracy and precision can be obtained only by the process of geodetic surveying" (Definitions of Surveying and Associated Terms, 1978, p.158).

Geographic Information Systems (G.I.S.) – "A category of computer programs and applications that are used to organize, analyze, and display spatial (geographic) data" (Ferguson, 1997, p.243).

Global Positioning System (G.P.S.) – "A generic term that refers to a satellite-based positioning system that gives a user's position anywhere on earth. Specific systems include NAVSTAR and GLONASS" (Ferguson, 1997, p.243).

Kinematic positioning - "Refers to applications in which the position of a non-stationary object (vehicle, ship, aircraft) is determined" (http://www.gmat.unsw.edu.au/snap/gps/about_gps.htm).

Multipath error - "Errors caused by the interference of a signal that has reached the receiver antenna by two or more different paths. This is usually caused by one path being bounced or reflected" (http://www.cgrer.uiowa.edu/cgrer_lab/gps/).

Photogrammetry - "The science or art of obtaining reliable measurements by photography" (Definitions of Surveying and Associated Terms, 1978, p.124).

Plane table – "A device for plotting survey data directly from field observation. A plane table consists of a drawing board on a tripod with some type of sighting instrument, generally a telescopic alidade, to measure and plot angles graphically" (Definitions of Surveying and Associated Terms, 1978, p.125-126).

Plat - "A diagram drawn to scale showing all essential data pertaining to the boundaries and subdivisions of a tract of land, as determined by survey or protraction" (Definitions of Surveying and Associated Terms, 1978, p.126).

Post-processed G.P.S. - "In post-processed G.P.S. the base and user (or roving or mobile) receivers have no data communication link between them. Instead, each receiver records the satellite observations that will allow differential correction, or the processing of double-differenced observables at a later time. Data processing software is used to combine and process the data collected from these receivers" (http://www.gmat.unsw.edu.au/snap/gps/about_gps.htm).

Precision Code (P-Code) - "It is used in the Precise Positioning Service (PPS) to reduce error due to atmospheric conditions and to avoid the effects of selective availability" (Ferguson, 1997, p.245).

Real-time kinematic - "The relative positioning procedure whereby carrier phase measurements (or corrections) are transmitted in real-time from a reference or base station to the user's roving receiver" (http://www.gmat.unsw.edu.au/snap/gps/about_gps.htm).

Rover - "Any mobile G.P.S. receiver collecting data during a field session. The receiver's position may be computed relative to another, stationary G.P.S. receiver at a base station" (http://www.gmat.unsw.edu.au/snap/gps/about_gps.htm).

Selective availability - "The intentional degradation of G.P.S. signals available to civilian users so that their position fixes are less accurate" (Ferguson, 1997, p.245).

Static positioning - "Location determination when the receiver's antenna is presumed to be stationary on the earth. Static positioning is usually associated with G.P.S. surveying techniques, where two G.P.S. receivers are static for some observation period which may range from minutes to hours" (http://www.gmat.unsw.edu.au/snap/gps/about_gps.htm).

Surveying - "The science and art of making all essential measurements in space to determine the relative position of points and/or physical and cultural details above, on, or beneath the surface of the earth and to depict them in usable form, or to establish the position of points and/or details" (Definitions of Surveying and Associated Terms, 1978, p.160).

Theodolite – "A precision surveying instrument consisting of an alidade with a telescope. It is mounted on an accurately graduated circle and is equipped with necessary levels and reading devices" (Definitions of Surveying and Associated Terms, 1978, p.164).

Topography - "The features of the actual surface of the earth considered collectively as to form. A single feature such as a mountain or valley is termed a topographic feature" (Definitions of Surveying and Associated Terms, 1978, p.170).

Total Station – "An electronic survey instrument that can simultaneously and automatically measure both distances and angles" (Van Goethem, 1992, p.11).

Transit – "A surveying instrument composed of a horizontal circle graduated in circular measure and an alidade with a telescope which can be reversed in its supports without being lifted therefrom" (Definitions of Surveying and Associated Terms, 1978, p.171).

Traverse - "A method of surveying in which lengths and directions of lines between points on the earth are obtained by or from field measurements, and used in determining positions of the points" (Definitions of Surveying and Associated Terms, 1978, p.172).

Chapter 2

REVIEW OF LITERATURE

Introduction

This chapter will cover in detail how G.P.S. has arrived at the forefront of today's surveying profession. The technological improvements leading up to G.P.S. will be covered along with an overview of how this system works. Advantages of G.P.S. along with examples of how it is being used to make surveying easier will be presented. The chapter will conclude with a discussion on the educational institutions in Wisconsin that offer land surveying programs and what their curriculum currently covers.

Technological improvements

Surveying technology of today has surpassed equipment that was considered standard as recently as 10 years ago. A major factor in this technological revolution occurred during the mid to late 1980's with the invention of total stations. These devices revolutionized land surveying the same way computers revolutionized the business world. Before the introduction of total stations, surveyors used tools such as the transit, compass, plane table, and steel tapes. All field data was recorded in field books and plotted by hand. The final product was then hand drafted in ink back at the office. One can imagine the problems associated with this system including lost data and the potential for making mistakes. For example, earlier surveyors had to convert measured slope distances into true horizontal distances. They did this by multiplying the slope distance by the cosine of the measured vertical angle. If an angle or distance were entered wrong, errors would begin to propagate. The total station, which is an electronic measuring device, significantly reduces the possibility of human errors. A total station electronically measures both horizontal and vertical angles. It also measures the slope distance and converts it into a true horizontal distance. These measurements are stored in a data collector that can then be downloaded into computer-aided drafting software. This software can then be used to convert the raw field data into a detailed map. The amount of time saved and the quality of measured data has played a vital part in the surveying industry (Luke, 1996).

Recently a few surveying firms have begun using the latest surveying technology to hit the market. This technology, called G.P.S., is making the work of surveyors even more efficient. G.P.S. enables surveyors to be in the field and take measurements alone. Due to the satellites, there is no longer a need for two or more people to clear lines of sight (Luke, 1996).

The most recent improvement of G.P.S. is called real time kinetic. This advancement allows surveyors who use a rover receiver and base station to obtain the coordinates and elevations they need within a matter of seconds. Before this technology was available, data was recorded and then imported into a computer to be calculated. Surveyors can now accomplish more work in a single day because the information they need is right at their fingertips (Luke, 1996).

How G.P.S. works

Someone who is not familiar with G.P.S. might be wondering how satellites in the sky could possibly be used to survey points here on the ground. The specific details behind how G.P.S. determines positions are beyond the scope of this study, however some basic knowledge of how it works will be helpful. The global positioning system is a configuration of 24 satellites that allow receivers to compute their exact position anywhere on the earth with remarkable accuracy. The 24 orbiting satellites send signals to ground receivers, which can be thought of as very accurate stop watches. The receiver measures the difference between the time when the signal is received and the time it should have been sent. This difference then allows the receiver to calculate the distance back to the sending satellite. This distance is calculated by multiplying the time it takes the radio signal to travel from the satellite to the receiver by the speed of the signal (the speed of light). Receivers need signals from at least four different G.P.S. satellites in order to fix the user anywhere on earth (Nord & Jabon, 1997). The timing involved with G.P.S. is the most crucial part of its operation. The slightest error in the recording time of the signal can cause a significant amount of error. For this reason, each satellite contains four atomic clocks that keep extremely accurate time (Ferguson, 1997).

Advantages of using G.P.S.

It is unlikely that G.P.S. will completely replace conventional surveying methods. G.P.S. will not function in locations with numerous overhead obstructions such as heavily forested areas. For this reason, surveyors must still rely on their conventional instruments. G.P.S. does however have many distinct advantages over conventional methods. G.P.S. saves time and money on projects. A surveyor does not have to rely on a conventional monument system that could have errors. Intervisibility between points is no longer required which eliminates the need for clearing lines of sight. Most G.P.S. equipment can cover a five-mile radius which greatly reduces the number of equipment set-ups. G.P.S. field data can be downloaded directly into a computer, which reduces the chances for errors that are likely to occur with manual input. G.P.S. works on a coordinate system of latitude and longitude. Due to this fact, many calculations are eliminated which significantly reduces office time (Pipe Line and Gas Industry, 1996). G.P.S. can also function day or night and in any type of weather.

One group that has realized the benefits of using G.P.S. is the Salem County Landfill in southern New Jersey. They used this system to survey the topography of their landfill. The results they obtained were more accurate and economical than aerial photography which was used in the past. This greater accuracy actually allowed the landfill to save $150,000 by delaying a $2 million construction project. In fact, the landfill will cover their costs of converting to G.P.S. in just one year. According to Pete de Wilde, executive director of the landfill, "We have the information we need to plan reliably, and we're saving money…what else can you want?" (Fralinger & Maxwell, 1997).

Nick Miller Inc. (N.M.I.), a Florida based surveying firm, has also benefited from using G.P.S. equipment. N.M.I. was involved in a 440-acre development project called Smith Farm. N.M.I. was in charge of surveying the project that would eventually contain 1,300 homes. N.M.I. performed much of the survey work with real-time kinematic (R.T.K.) G.P.S. The real-time system changed their view of G.P.S. as being just a part-time tool for large projects. N.M.I. efficiently used R.T.K. as an everyday tool during this project (Gordon, 1999).

One of the most important aspects of any development project is maintaining horizontal and vertical control. With construction going on, control points always seem to become obliterated. Prior to purchasing G.P.S., N.M.I. established control through conventional methods. This process was time consuming as new points were constantly established to replace those that were destroyed. G.P.S. has greatly changed this process. Destroyed control points can now be re - established very quickly by simply staking out the known coordinates of the lost points (Gordon, 1999).

The earthwork phase of this project required a large amount of staking. Water tracts, proposed locations of residences, and roadways were all staked. Using R.T.K. technology, the rover operator swiftly provided elevations for grading from location to location. While using G.P.S., N.M.I. was completing the work of several weeks in just a few days. N.M.I. also used R.T.K. to aid in the layout of underground utilities (Gordon, 1999).

N.M.I. has had considerable success using G.P.S. and R.T.K. The biggest benefit for them is the ability to respond quickly to client needs. G.P.S. is crucial for meeting deadlines that cannot be met by conventional methods (Gordon, 1999).

Until recently, most surveyors did not invest in G.P.S. due to certain factors.

Cost: Satellite signals have always been free, however, the hardware and software needed has been quite expensive. Leica and Ashtech, which are two companies that sell G.P.S. equipment, were contacted by phone to obtain an estimate of what it would cost to purchase specific G.P.S. systems. A representative from Leica indicated their real-time system, which includes a base station and rover receiver, sells for approximately $40,000. Leica also sells static and G.I.S. units. Static units can range from $17,000 to $30,000, and the G.I.S. units cost approximately $10,000. Post-processing software is not included in these prices. This software can be purchased for an additional $3,500.

According to a representative from Ashtech, their real-time system can be purchased for approximately $45,000 to $46,000. This price includes the base station, rover receiver, and post-processing software. Ashtech also handles static systems. A system which includes two single frequency receivers and post-processing software sells for approximately $9,000. Over time and with increased competition from manufacturers, the prices of G.P.S. will decrease. Manufacturers are also improving the capabilities of G.P.S.

Convenience: For years only a few satellites were in orbit which limited surveyors as to when they could make G.P.S. observations. Today more than 20 satellites are in orbit providing for 24-hour worldwide service (Van Sickle, 1996; Knott, 1999).

Applicability: The size, shape, cost, and accuracy of G.P.S. receivers are improving every year. Improvements in software also provide G.P.S. with more capabilities than ever before. G.P.S. has always had great potential, what is new today is how fast this potential has become a reality (Van Sickle, 1996).

G.P.S. and education

With this technology also comes the certain reality that today's land surveying graduates are going to have to become familiar with the use of G.P.S. in order to meet the changing demands of their profession. In years past, surveyors were not expected to be well trained in using G.P.S. In fact, a study was done by (Van Goethem, 1992), which focused on the competencies that students graduating from Wisconsin’s surveying programs should have. The results of his study found the following competencies related to surveying equipment to be the most important. Graduates are expected to operate a scientific calculator, theodolite, total station, data collector, E.D.M., automatic level, microcomputer, and land surveying cogo programs. In addition to these competencies, they are also expected to be familiar with computer-aided drafting and G.I.S. software. It is interesting to note that only 29.2 percent of the survey respondents in the study felt that being able to operate a G.P.S. receiver was very important (Van Goethem, 1992).

A comment from one respondent indicated that a surveyor should be able to understand how the observations are made and how to best utilize the information received from G.P.S. Another respondent felt that students should be taught principles in the latest technology because that is what they will be expected to know and use in the work force (Van Goethem, 1992).

Educating land surveyors in the use of G.P.S. will become extremely important in the future. The state of Wisconsin has numerous institutions offering surveying programs that meet the educational requirements for obtaining professional licensure in the state. According to the Wisconsin Department of Regulation and Licensing, the University of Wisconsin at Madison and Platteville both offer a Bachelor of Science degree in Civil Engineering with a surveying option. There are also five technical colleges in the state that offer surveying related programs. The technical college, along with its program title are as follows: Gateway Technical College - Land Surveying Technician; Madison Area Technical College - Public Works; Milwaukee Area Technical College - Civil Engineering / Public Works Technician; Nicolet Technical College - Land Survey Technician; and Northeast Wisconsin Technical College - Civil Engineering Technician.

Each school was contacted by phone or e-mail to find out if G.P.S. was covered in their current curriculum. According to Alan Vonderohe, the University of Wisconsin-Madison no longer has a separate accredited option in surveying within the Bachelor of Science degree in Civil Engineering. However, they do teach a number of courses in G.P.S. They teach a 3-credit course in Satellite and Inertial Surveying Systems that focuses on G.P.S. and also a 2 credit course in differential G.P.S. These courses provide students with both theory and hands-on experience with G.P.S. technology. They have both static and kinematic geodetic receivers and are hoping to upgrade to real-time soon. They also have a number of handheld receivers for the differential G.P.S. course.

According to Dr. Max Anderson, a professor at the University of Wisconsin-Platteville, students take one surveying course that covers all aspects of land surveying, including G.P.S. One G.P.S. unit is used in a lab setting to demonstrate the use of G.P.S. Students do not receive hands-on training with the equipment or use post-processing software.

A representative from Gateway Technical College stated that G.P.S. is currently not covered in their curriculum.

Jerry Mahun from Madison Area Technical College (M.A.T.C.) says that they offer a course solely on G.P.S. called Introduction to G.P.S. This course is offered to students as well as on an outreach basis for professionals. Jerry states that Real-Time Kinetic (R.T.K.) G.P.S. is not covered because of rapidly changing technology and the high cost of equipment.

Al Melbard from Milwaukee Area Technical College informed me that they have previously offered a course solely on G.P.S., but due to lack of enrollment, it was discontinued. The school does however cover G.P.S. topics in other courses that are currently offered. The students are instructed on how to operate static G.P.S. equipment. Students collect data using the equipment in a hands-on laboratory setting. This data is then used again in other projects. Students are exposed to post-processing software, but due to time constraints, do not receive any hands-on training with it.

Nicolet Technical College does not offer a course solely on G.P.S. but does provide a G.P.S. unit within its Survey III course. According to John Margitan, the unit covers general principles including the theory of how G.P.S. works. He goes on to say that equipment is vendor specific and too costly to justify large purchases. Students do use some static equipment for completing projects, and are exposed to post-processing software.

Northeast Wisconsin Technical College (N.W.T.C.) does offer a course on G.P.S. According to Rick VanGoethem, basic principles are covered along with hands-on training. Students work in groups and perform static, kinematic, and R.T.K. projects. Students are also required to perform post-processing on projects. Rick mentions that N.W.T.C. would like to update their equipment within the next year if their budget allows.

Summary

The duties of a land surveyor have not changed much since the 1800's. Today surveyors still determine land boundaries, stake out roads and right of ways, write legal descriptions, and prepare official plats and maps that show the shape and area of tracts and their subdivisions into smaller parcels. One thing that has changed over time, however, is the equipment that is used by surveyors. Changes in the way measurements are made have greatly affected the way data is collected. Many technological advancements have been made in the surveying industry. These rapid changes in technology mean professionals can accomplish much more work while achieving more precise and efficient results.

Chapter 3

METHODOLOGY

Introduction

This study used descriptive research techniques involving the collection of data from Land Surveyors in the state of Wisconsin. The study focused on the competencies related to G.P.S. that are needed by Wisconsin's land surveying graduates. The procedures used in this study were divided into the following steps:

1.) selection of the subjects to be included in the study

2.) design of the instrument (survey questionnaire)

3.) procedure

4.) data analysis

Selection of the Subjects

The subjects of this study were land surveyors practicing in the state of Wisconsin. A 1999 directory of county surveyors and land surveying firms in the state of Wisconsin was obtained from the Wisconsin Society of Land Surveyors. From this list, half the number of firms for each county were selected at random. In the case of a county having an odd number of firms, the number selected was rounded down to the nearest whole number. This process resulted in a final sample size of 145 surveying firms. Time and money made using a larger sample for this study impractical.

Instrumentation

A survey questionnaire was the instrument used to gather data and was developed by the researcher of this study. The content validity was supported from 2 main sources: the contents of a Plan B Thesis titled “Survey of the occupational competencies needed for graduates of a bachelor of science degree in land surveying as recommended by registered land surveyors in the state of Wisconsin” (Van Goethem, 1992), and from the literature review done by the researcher.

The survey questionnaire is divided into two sections. Section I begins by asking the respondent what type of work they perform and how many people they employ. The survey then asks if the respondent uses G.P.S. for land surveying. The firms that don't are asked to give reasons why. This group is then instructed to stop at this point. The firms who answer yes are to continue by answering further questions about G.P.S. Section II of the questionnaire contains two columns, and allows the respondent to rate both the competencies and subject areas that are related to G.P.S. The ratings for each column are based on the Lichert rating scale with three levels. Column A rates the level of importance for each competency and subject area with one (1) being "not important", two (2) "important", and three (3) "essential". Column B has a rank for the extent to which new employees have been adequately prepared with one (1) being "none", two (2) "somewhat prepared", and three (3) "completely prepared". The final question allows the respondent to offer suggestions on how to improve G.P.S.

Procedures

The first draft of the questionnaire was distributed to three Registered Land Surveyors in the Menomonie, Wisconsin area. The questionnaire and cover letter were personally delivered to this “pilot study” group and was completed in the presence of the researcher. This allowed the researcher to answer any questions and to receive feedback on the clarity of the questions being asked. “Some authors suggest trying out all of your procedures on a small scale, including your introductory letter and your data collection phases” (Mangione, 1995, p.24). The pilot study group was satisfied by the layout and clarity of the questionnaire, therefore no modifications were made. Appendix A shows the cover letter that was used in this study. Appendix B shows the questionnaire that was mailed out.

On January 3, 2000, the questionnaire along with a cover letter and return envelope were mailed out to the 145 randomly chosen land surveying firms. Each questionnaire contained an identification number for mailing purposes only. This identifier was used by the researcher to keep a record of which firms returned their questionnaire. Company names were never attached to the questionnaire in order to ensure complete confidentiality.

The initial mailing of 145 surveys resulted in 100 being returned for a 69% rate of return. A second mailing was not done due to time and money constraints.

Data analysis

The results from Section 1 (questions 1 through 10) will be tabulated and shown in the format of a table. A brief discussion will follow each table. For Section 2, the means and standard deviations for each category will be computed and shown in tables. A brief discussion will also follow these tables. The final question of the survey contains comments from respondents. A complete list of the responses will be provided.

Chapter 4

DATA ANALYSIS

Introduction

The purpose of this study was to determine specific information on G.P.S. skills, knowledge and equipment presently being used in the land surveying industry. This study used descriptive research techniques involving the collection of data from land surveyors in the state of Wisconsin. This data is presented in the following tables. In addition to the quantitative data presented, the investigator has also summarized some of the qualitative comments provided by the respondents.

Table 1
Main type of company service

Type of Service	Number
Construction surveying	40
Rural boundary surveys	68
Urban boundary surveys	45

The first survey question dealt with the main type of service that was performed by each company. More than one response was common, therefore percentages were not calculated, only the number of actual responses were recorded. Rural boundary surveys was the most common type of service performed, receiving 68 responses. Table 1 shows a summary of the responses.

Table 2
Total number of company employees

# of employees	Number	Percentage
0-5	52	52%
6-10	22	22%
11-20	12	12%
21-40	5	5%
>40	9	9%
Total	100	100%

In the area of total number of employees, the category of 0-5 employees had the greatest frequency, which accounted for 52% of the responses. The next largest category was 6-10 employees, which accounted for 22% of the responses. Percentages for the remaining categories are shown in Table 2.

Table 3
G.P.S. use among survey firms

Use	Number	Percentage
Yes	30	30%
No	70	70%
Total	100	100%

Question 3 was designed to separate the firms that use G.P.S. from the firms that don't. Table 3 shows that 30% of the respondents do use G.P.S. equipment in performing survey work while 70% do not. It is these 30% of the respondents that provided the information for the remainder of the survey. The respondents who don't use G.P.S. were asked to give reasons why.

Table 4
Reasons for not using G.P.S.

Reason	Number
Cost of equipment	52
Lack of technical knowledge	7
Lack of need	45

The reasons for not using G.P.S. were explored in question 4. More than one response was common, therefore percentages were not calculated, only the number of actual responses were recorded. Cost of equipment was the most common reason for not using G.P.S., receiving 52 responses. Table 4 shows a summary of the responses for this question.

Many additional comments were made regarding this question.

Comments from respondents-

- For what it's worth – although we don't own, the expense-utilization ratio is high. We do use county generated data on a daily basis. It is important to know how this data is generated and an understanding of errors. (Standard Errors)
- The conventional total station can perform many tasks without the large outlay of money for a G.P.S. system.
- With a conventional two person survey crew potentially charging the time of both individuals with G.P.S., which is generally a one person crew, the "billable time" is reduced by half. Convincing owners differently that G.P.S. can make money by being able to do more in a short amount of time.
- 75% of our surveys are within the tree canopy. When trees are no longer an obstacle we will probably use G.P.S.

- We made the decision recently to purchase a robotic total station rather than G.P.S. due to our survey applications.
- I only survey part-time and although the need is there on most projects, I can't justify the cost.
- I've resisted purchasing G.P.S. to this point, but expect that I will soon be making the investment very soon – this winter.
- Use of equipment is limited to open areas.
- Not enough reasons to justify cost and learning curve at this point.
- Dense tree cover in my area does not make G.P.S. cost-effective on all surveys at this time. I expect that to change in the very near future.
- Section corners are monumented and coordinated in our area.
- I am waiting for the technology to advance and the cost to decrease.
- I only do lot and small farm surveys. If I were to do large scale mapping, I would use G.P.S.
- The need is definitely there, however the equipment is too costly.

Table 5
Main reason for using G.P.S.

Reason	Number	Percentage
Accuracy of Results	8	27%
Saves time & money	22	73%
Operation in any type of weather	0	0%
Total	30	100%

Question 5 asks the respondents who are using G.P.S. to provide the main reason they are using G.P.S. Operation in any type of weather is a very important advantage of using G.P.S., however none of the respondents selected this as the main reason for using it. Even though G.P.S. is capable of producing results in rain, snow, fog, etc., most surveyors do not work in these conditions for extended periods of time. Saving time and money had the highest percentage of responses with 73%. Accuracy of results accounted for the remaining 27% of the responses. Percentages for the responses are shown in Table 5.

There were some additional comments from the respondents regarding this question.

Comments from respondents-

- To keep up with current technology
- Job specifications
- Surveys over much greater distances are more quick and easy
- To acquire data from widely spaced control points.

Table 6
Number of years using G.P.S.

Years	Number	Percentage
0-1	5	17%
2-4	17	56%
5-8	6	20%
9-12	2	7%
>12	0	0%
Total	30	100%

Question 6 asks the respondent to indicate how long they have been using G.P.S. for survey work. The category of 2-4 years received the highest percentage of responses with 56%. None of the respondents have used G.P.S. for more than 12 years. Percentages for all the categories are shown in Table 6.

Table 7
Types of work G.P.S. is used for

Type of work	Number
Topographic surveying	24
Boundary surveys	28
Geodetic control	17
Construction staking	10
Photogrammetric ground control	17
G.I.S.	7

Question 7 deals with what type of work G.P.S. is being used for. More than one response was common, therefore percentages were not calculated, only the number of actual responses were recorded. Boundary surveys was the most common response for this question receiving 28 responses. Topographic surveying was the next highest category with 24 responses. In the category of other, 3 respondents indicated they use G.P.S. for re-monumenting public land survey corners. Additional responses included section summaries and right-of-way plats. Table 7 shows a summary of the responses for this question.

Table 8
Type of system currently being used

Type of system	Number
Static	13
Real-Time	22
G.I.S.	2
Hand-held	1

Question 8 asks the respondent to indicate what type of G.P.S. system they are currently using. More than one response was common, therefore percentages were not calculated, only the number of actual responses were recorded. Real-time was the most common response for this question receiving 22 responses. Static was the next highest category with 13 responses. Table 8 shows a summary of the responses for this question.

Table 9
How G.P.S. has affected productivity

Productivity Change	Number	Percentage
Increased	25	83%
Decreased	0	0%
No Change	5	17%
Total	30	100%

Question 9 asks the respondent to indicate how G.P.S. has affected their productivity. Increased productivity was reported by 83% of the respondents, while 17% felt there was no change in their productivity by using G.P.S. None of the respondents indicated that G.P.S. decreased their productivity. The responses for this question are shown in Table 9.

Table 10
Reason for company provided training

Reason	Number
Change in technology since graduation	25
Provide skills in a supporting technical area	14
Expand specialization in the field	15
Deficiencies in undergraduate education	9
Not necessary	2

Question 10 allowed the respondent to indicate why company provided training was needed by entry-level surveyors. More than one response was common, therefore percentages were not calculated, only the number of actual responses were recorded. Two of the respondents felt that G.P.S. training was not necessary for their entry-level surveyors. The most commonly cited reason for providing training, receiving 25 responses, was to upgrade skills associated with changing technology since graduation. The remaining responses are summarized in Table 10.

Section 2 of the questionnaire allowed the respondents to rate the importance of several competencies and subject areas that are related to G.P.S. They were also required to rate the extent to which new employees have been adequately prepared in these competencies and subject areas prior to employment.

Table 11
Competencies: Importance and Preparation

	Importance		Preparation	
Competency	Mean	S.D.	Mean	S.D.
Measure antennae height	2.63	0.61	2.16	0.80
Prepare & interpret station descriptions	2.37	0.67	2.08	0.70
Use post-processing software	2.40	0.72	1.64	0.64
Interpret ephemeris information	2.17	0.65	1.68	0.63
Operate a G.P.S. data collector	2.77	0.57	1.88	0.67
Set up a base station	2.77	0.50	1.72	0.68
Operate a rover receiver	2.77	0.43	1.72	0.74
Leveling over a point	2.80	0.48	2.32	0.75

Under the importance column of competencies, leveling over a point received the highest rating of 2.80. Three competencies were tied for second with a mean of 2.77. They were operate a G.P.S. data collector, set up a base station, and operate a rover receiver. Under the preparation column, leveling over a point again received the highest rating of 2.32. Being able to measure antennae height received the next highest rating of 2.16. A complete list of the means and standard deviations for each competency is listed in Table 11.

Table 12
Education: Importance and Preparation

	Importance		Preparation	
Subject Area	Mean	S.D.	Mean	S.D.
Geodesy	1.97	0.56	1.80	0.58
Conversion of coordinate systems	2.70	0.47	1.80	0.65
Post-processing of raw data	2.43	0.68	1.56	0.65
G.P.S. principles of operation	2.57	0.57	2.00	0.65
Limitations of G.P.S.	2.77	0.43	1.72	0.74
Understanding accuracy	2.87	0.35	1.84	0.69

Under the importance column of education, understanding accuracy received the highest rating of 2.87. Limitations of G.P.S. received the next highest rating of 2.77. Under the preparation column, G.P.S. principles of operation received the highest rating of 2.00. Understanding accuracy came in second with a rating of 1.84. A complete list of the means and standard deviations for each subject area is listed in Table 12.

Question 11 was the final question on the survey. It was an open-ended question that allowed the respondent to suggest improvements that would make G.P.S. better. The following is a list of the responses.

Comments from respondents-

- smaller, cheaper, more satellites, and a better radio link
- on real-time make it easier to perform calculations
- lighter, no cables, operate with accuracy in cover better
- more user-friendly software and affordable training by suppliers
- software for multipath
- better vertical control stations; less expensive

- Educate the younger generation to the fact that G.P.S. is not a fix all. We are using an imperfect system and G.P.S. shouldn't be used to perfect it. People think it makes "professionals" out of mere technicians. – NO
- station offsets, staking calculations, on board COGO, P2 information manipulation, improvement of connectivity issues
- regional base stations

Some additional comparisons were made from the results of this study. The results are presented in the following tables:

Table 13
G.P.S. use based on type of service provided

	Use G.P.S.					
Type of Service	Yes		No		Total	
Construction surveying	11	(27.5%)	29	(72.5%)	40	(100%)
Rural boundary surveys	24	(35.3%)	44	(64.7%)	68	(100%)
Urban boundary surveys	10	(22.2%)	35	(77.8%)	45	(100%)

For the firms that perform construction surveying, 72.5% do not use G.P.S. compared to 27.5% who do. It should also be noted that many firms did select more than one type of service, (i.e. a firm that used G.P.S. might have performed both rural and urban boundary surveys). The results for the other types of services are shown in Table 13.

Table 14
G.P.S. use based on company size

	Use G.P.S.					
Number of employees	Yes		No		Total	
0-5	8	(15.4%)	44	(84.6%)	52	(100%)
6-10	10	(45.5%)	12	(54.5%)	22	(100%)
11-20	4	(33.3%)	8	(66.7%)	12	(100%)
21-40	2	(40.0%)	3	(60.0%)	5	(100%)
>40	6	(66.7%)	3	(33.3%)	9	(100%)

For the companies that had 0-5 employees, 15.4% of them did use G.P.S. in performing survey work while 84.6% did not. The results for the remaining categories are shown in Table 14.

Table 15
G.P.S. System used based on type of service performed

	Type of Service			
Type of system	Construction	Rural	Urban	Total
Static	6	11	5	22
Real-Time	9	17	7	33
G.I.S.	1	1	1	3
Hand-held	0	1	0	1

Many firms indicated that they perform more than one type of service, therefore percentages were not calculated. The actual number of responses were the only data tabulated. For the firms using static systems, 6 performed construction surveys, 11 performed rural surveys and 5 performed urban surveys. A summary of results for the other systems are shown in Table 15.

Table 16
G.P.S.'s affect on productivity based on type of service performed

	Type of Service			
Productivity Change	Construction	Rural	Urban	Total
Increased	9	19	8	36
Decreased	0	0	0	0
No Change	2	5	2	9

Many firms indicated that they perform more than one type of service, therefore percentages were not calculated. The actual number of responses were the only data tabulated. For the firms indicating their productivity increased, 9 performed construction surveys, 19 performed rural surveys and 8 performed urban surveys. A summary of results for the remaining categories are shown in Table 16.

Chapter 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

This section provides a brief overview of the study. It contains a restatement of the problem as well as the methods and procedures that were used in the collection of data.

Restatement of the Problem

The purpose of this descriptive study was to determine specific information on G.P.S. skills, knowledge, and equipment presently being used in the land surveying industry. Many professional land surveyors in the State of Wisconsin have recently invested in G.P.S. technology. This technology is fairly new to surveyors as well as to graduates of land surveying programs across the state. Most surveying programs expose students to different aspects of G.P.S., however, a study has never been done to determine professional's perceptions of what graduates should know about G.P.S. to be employed. Land surveying graduates may not have adequate knowledge and training about G.P.S. to meet the needs of surveying firms. A guide is needed to determine how much knowledge of G.P.S. graduates should have to be successful in today's workforce.

Methods and Procedures

This study used descriptive research techniques involving the collection of data from land surveyors in the state of Wisconsin. The study focused on the competencies related to G.P.S. that are needed by Wisconsin's land surveying graduates.

The subjects of this study were lands surveyors practicing in the state of Wisconsin. A 1999 directory of county surveyors and land surveying firms in the state of Wisconsin was obtained from the Wisconsin Society of Land Surveyors. From this list, 145 surveying firms were randomly selected.

A survey questionnaire was the instrument used to gather data and was developed by the researcher of this study. The survey questionnaire was divided into two sections. Section I contained a broad range of basic questions, while Section II required the respondent to rate both the competencies and subject areas that are related to G.P.S. The survey concludes by allowing the respondent to offer suggestions on how to improve G.P.S.

On January 3, 2000, the questionnaire, along with a cover letter and return envelope were mailed out to the 145 randomly chosen land surveying firms. The initial mailing yielded 100 responses for a 69% rate of return.

The questionnaire was designed to answer the following questions:

1.) How widely used is G.P.S. by Wisconsin surveying firms?

2.) Is there a relationship between using G.P.S. and company size?

3.) What competencies related to G.P.S. should graduates be able to perform on the job?

4.) What are surveyor's perceptions of student preparedness regarding G.P.S. competencies?

5.) What subject areas related to G.P.S. do surveyors feel are the most important for entry-level employees to know?

6.) What are surveyor's perceptions of student preparedness in subject areas related to G.P.S.?

Conclusions

This section will provide a summary of the conclusions based on the findings of the study. The major findings of the study will be presented along with some additional findings that the researcher thought were important.

Major findings

- In response to the above questions, the results of the study indicate that 30% of the firms surveyed do use G.P.S. in performing survey work, while 70% do not. The percentage of firms that do use G.P.S. seems to be slightly higher than the researcher had anticipated. G.P.S. is a fairly new technology, not to mention a very costly investment compared to traditional equipment.

- Responses from question 4 of the survey help to validate this point. This question asked the respondents who don't use G.P.S. to provide reasons why. "Cost of equipment" was the category that received the highest frequency with 52 responses. Many surveyors, who indicated there was a need for using G.P.S., felt they could not justify the high cost of purchasing the equipment.

- Other surveyors felt there simply was a lack of need for using G.P.S. One respondent indicated that today's total stations can perform many tasks without the large outlay of money for a G.P.S. system. Numerous other respondents commented on the large amount of tree cover in their area, which is not conducive to using G.P.S. It is the researcher's belief that advances in technology coupled with more affordable pricing will lead to more firms purchasing G.P.S. equipment in the future.

- The results of this study indicate that there is a relationship between company size and whether or not a firm will use G.P.S. For the smallest firms (0-5 employees), 84.6% indicated that they do not use G.P.S. compared to 15.4% who said they do. When looking at the largest firms (> 40 employees), only 33.3% do not use G.P.S. compared to 66.7% who said they do. Large firms are more likely to be using G.P.S. because they have greater financial resources. They are also more likely to be involved in larger projects where G.P.S. has proven to be cost-effective.

- In the area of G.P.S. competencies, leveling over a point received the highest rating. G.P.S. base stations must be leveled over a point before observations are begun. A receiver that is not level over a point will introduce errors in any measurements made. For this reason, this competency is extremely important as was indicated by the respondents.

- The respondents also felt that setting up a base station, and being able to operate a rover receiver and G.P.S. data collector were very important. Making measurements with G.P.S. requires being able to correctly set up a base station. With real-time equipment, a surveyor must also be familiar with using a G.P.S. data collector. The data collector is a crucial part of any G.P.S. system. It allows the user to perform calculations and store raw data.

- The respondents in this study felt that new employees had the most preparation with leveling over a point. This competency is required not only for G.P.S. work, but also for many types of applications using conventional equipment. Leveling over a point is an essential competency that any surveyor should be able to perform.

- The respondents felt that students were the least prepared at using post-processing software. One reason for this could be that students do not receive enough hands-on training using the equipment. Many of the schools that were contacted indicated they did cover post-processing, but not with a hands-on approach. Also, with the advent of real-time systems, post-processing no longer needs to be done.

- The surveyors in this study felt that the most important subject area related to G.P.S. was understanding accuracy. Being aware of the limitations of G.P.S. was also rated very highly. Employers would like graduates to realize that although G.P.S. is capable of extremely accurate results, it does have its limitations. As one respondent stated, "…G.P.S. is not a fix all. We are using an imperfect system and G.P.S. shouldn't be used to perfect it." Graduates need to realize that G.P.S. does not always produce accurate results.

- The respondents from this study felt that students were not completely prepared in any of the subject areas listed. G.P.S. principles of operation received a rating of 2.00 which indicates that surveyors felt students were "somewhat prepared" in this subject. The remaining subjects all received ratings of less than 2.00. A reason for this lack of preparation may be due to the fact that some schools do not provide courses solely on G.P.S. G.P.S. is sometimes covered as a unit in other courses. It is the researcher's belief that courses, focusing solely on G.P.S., are needed to adequately expose students to the main subject areas of G.P.S.

Additional findings

- A comparison was made to determine if the type of work a firm performed had any impact on whether or not they would use G.P.S. Based on the percentages of responses, there was no significant relationship between using G.P.S. and the type of work performed.

- A comparison was also made between the type of work performed and the type of G.P.S. system being used. Based on the number of responses, the firms performing rural boundary surveys were more likely to use either static or real-time G.P.S. than firms performing construction staking or urban boundary surveys. Urban boundary surveys and construction staking usually don't require lengthy traverses. Rural surveys, however, often involve traversing the entire boundary of a section. Section corners are sometimes not intervisible due to obstructions such as trees, hills, etc. For this reason, it is very practical to use G.P.S. for rural boundary surveys. The small number of responses for G.I.S. and hand-held systems did not prove to be significant in this study.

- The researcher wished to determine if G.P.S.'s affect on productivity was related to the type of service performed. Based on the number of responses, firms performing rural boundary surveys were much more likely to see an increase in productivity. The researcher believes that using G.P.S. in rural areas eliminates the need for lengthy traverses within a section. G.P.S. will definitely increase productivity by decreasing the time it takes to conventionally traverse an entire section.

- The firms not using G.P.S. have indicated that cost of equipment and lack of need are the two main reasons they have resisted purchasing the equipment. Many respondents simply do not have the financial resources required to purchase G.P.S. equipment. Others have indicated that a majority of their work is in dense tree cover where G.P.S. would not be able to function. Many firms feel there is a lack of need for using G.P.S. because today's conventional instruments can perform many tasks for a fraction of the cost required to purchase G.P.S. Lack of technical knowledge was not a critical factor in deciding to purchase G.P.S.

Recommendations

The researcher of this study has developed a list of recommendations that would be helpful for anyone who wishes to do further research on this topic. The recommendations are broken down into two categories; recommendations related to this study, and recommendations for further study.

Recommendations related to this study:

1.) Results of this study should be distributed to the universities and technical colleges in the state of Wisconsin that offer programs in land surveying.

2.) The results of this study should be used as a guide to revise and update future curriculum in land surveying programs.

3.) Question number one of the survey should be modified. “Check only one” should be inserted at the end of the question. Having only one answer for this question would make it possible to compute percentages when making comparisons during the data analysis phase of the study.

4.) An additional question should be added asking the respondent to indicate what geographic area of the state they work in. This would be useful in determining if G.P.S. is more widely used in open vs. forested areas.

Recommendations for further study:

1.) It is recommended that similar studies related to this one be done in other states that offer surveying degrees. Surveyors in other states may have different opinions on what should be taught about G.P.S.

2.) Duplicate this study in several years to determine if G.P.S. technology as well as surveyor’s perceptions regarding it have changed.

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APPENDIX A

COVER LETTER

January 3, 2000

Tom Carlson
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Menomonie, WI 54751

Dear Fellow Land Surveyor,

As a land surveyor you know that surveying technology has greatly improved in the last 10 years. With the advent of Global Positioning Systems (G.P.S.) technology, surveyors are now offered a new way to collect and store data. With this technology also comes the certain reality that today's land surveying graduates are going to have to become familiar with the use of G.P.S. in order to meet the changing demands of their profession.

Enclosed you will find a questionnaire to determine your perceptions of what graduates should know about G.P.S. to be employed. Your company has been selected along with 144 other land surveying companies in the state of Wisconsin to share your ideas and opinions regarding G.P.S. Your company was drawn in a random sample from companies throughout the entire state. In order that the results will truly represent the thinking of surveyors in the state of Wisconsin, it is important that each questionnaire be completed and returned.

You may be assured of complete confidentiality. The questionnaire has an identification number for mailing purposes only. This is so that I may check your name off of the mailing list when your questionnaire is returned. Your name will never be placed on the questionnaire.

The information you provide will be used in my master's thesis and will help to establish a guide for the education of students in the land surveying profession. Copies of the results of this study will be sent to the universities and technical colleges in Wisconsin that currently have land surveying programs.

I realize your time is valuable therefore I would like to thank you in advance for your cooperation in filling out this questionnaire. Please return the questionnaire in the enclosed stamped envelope. I would be most happy to answer any questions you might have. Please write or call. The telephone number is (715) 664-8580.

Thank you for your assistance.

Sincerely,

Tom Carlson
Land Surveyor in Training
Graduate Student (Vocational Education)
University of Wisconsin – Stout

APPENDIX B

QUESTIONNAIRE

Global Positioning Survey

Directions:

This study is being conducted to gather information about the use of Global Positioning Systems (G.P.S.) by land surveyors and what competencies potential employees need to have in order to be successful in the workforce. Please read each question carefully and check the box that best answers each question.

SECTION 1

1) What is the main type of service that your company performs?
   - ☐ construction surveying
   - ☐ rural boundary surveys
   - ☐ urban boundary surveys

2) How many people does your company employ?
   - ☐ 0-5 employees
   - ☐ 6-10 employees
   - ☐ 11-20 employees
   - ☐ 21-40 employees
   - ☐ >40 employees

3) Does your firm use G.P.S. equipment in performing survey work?
   Yes No
   If yes, skip to question #5. If no, complete only question #4 and stop.

4) What statement best describes why you don't use G.P.S. (check all that apply)
   - ☐ cost of equipment
   - ☐ lack of technical knowledge
   - ☐ lack of need
   - other ____
   ____

5) What is the main reason you are using G.P.S.? (check only one)
   - ☐ accuracy of results
   - ☐ saves time and money
   - ☐ operation in any type of weather
   - other ____
   ____

6) How long have you been using G.P.S. for survey work?
   - ☐ 0-1 years
   - ☐ 2-4 years
   - ☐ 5-8 years
   - ☐ 9-12 years
   - ☐ >12 years

7) What types of work do you use G.P.S. for? (check all that apply)
   - ☐ topographic surveying
   - ☐ boundary surveys
   - ☐ geodetic control
   - ☐ construction staking
   - ☐ photogrammetric ground control
   - ☐ G.I.S.
   - Other ____
   ____

8) What type of system are you currently using? (check all that apply)
- ☐ static only
- ☐ real time
- ☐ G.I.S.
- ☐ hand-held

9) Overall, how do you feel G.P.S. has affected your productivity?
- ☐ increased
- ☐ decreased
- ☐ no change

10) Company provided G.P.S. training for entry level surveyors was: (check all that apply)
- ☐ necessary to upgrade skills associated with changing technology since graduation
- ☐ necessary to provide skills in a supporting technical area
- ☐ necessary to expand specialization in the field
- ☐ necessary because of deficiencies in undergraduate education
- ☐ not necessary

SECTION 2

<u>**Directions:**</u> The column on the left contains competencies and subject areas that are related to G.P.S. In **Column A**, rate the **importance** of each competency and subject. The more critical and frequent it is to doing your job, the more important it is. In **Column B**, rate the extent to which you feel new employees have been **adequately prepared** prior to employment. Use the following ratings:

A. Importance	B. Preparation
1=NI=Not Important	1=N=None
2=I=Important	2=S=Somewhat Prepared
3=E=Essential	3=C=Completely Prepared

	A. Importance			B. Preparation		
	NI	I	E	N	S	C
	1	2	3	1	2	3
Competencies:						
Measure antennae height………………………….	1	2	3	1	2	3
Prepare & interpret station descriptions…………..	1	2	3	1	2	3
Use post-processing software……………………..	1	2	3	1	2	3
Interpret ephemeris information…………………..	1	2	3	1	2	3
Operate a G.P.S. data collector……………………	1	2	3	1	2	3
Set up a base station……………………………….	1	2	3	1	2	3
Operate a rover receiver…………………………...	1	2	3	1	2	3
Leveling over a point………………………………	1	2	3	1	2	3
Education:						
Geodesy ……………………………………………	1	2	3	1	2	3
Conversion of coordinate systems (geodetic to grid & vice versa)…………………….	1	2	3	1	2	3
Post-processing of raw data………………………..	1	2	3	1	2	3
G.P.S. principles of operation……………………...	1	2	3	1	2	3
Limitations of G.P.S……………………………….	1	2	3	1	2	3
Understanding accuracy……………………………	1	2	3	1	2	3

11) What improvements, if any, would you suggest to make G.P.S. better?

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