IMPLEMENTATION OF GPS TRACKING SYSTEM TO IMPROVE TRANSPORTATION EFFICIENCY: A CASE OF AN INDUSTRIAL COMPONENT MANUFACTURER

By

JUTHAMANEE KOWAWISARAT

A Final Report of the Six-Credit Course
SCM 2202 Graduate Project

Submitted in Partial Fulfillment of the Requirements for the Degree of
MASTER OF SCIENCE IN SUPPLY CHAIN MANAGEMENT

Martin de Tours School of Management
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Implementation of GPS Tracking System to improve transportation efficiency: a case of an industrial component manufacturer.

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I confirm that this thesis/project has been carried out under my supervision and it represents the original work of the candidate.

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Juthamanee Kowawisarat
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November 2011

ABSTRACT

In the current context, technology allows business to work easily and efficiently since the information can be transmitted rapidly, i.e. at the actual time. The GPS tracking system is one of the popular tools that can be applied to firms to improve logistics and transportation service. To solve inefficiency in truck transportation of the CVC, a GPS tracking system is designed. There are three main objectives of this study; 1) to understand the application of the GPS tracking system; 2) To develop a plan to implement a GPS tracking system; and 3) to verify possible outcomes of the implementation of a GPS tracking system. To achieve these objectives, both quantitative and qualitative data is gathered by document review, in-depth interview and observation. A cause and effect diagram is used to analyze the root cause of a low transportation efficiency problem. After implementation of the GPS tracking system, work overtime, idle time, driver utilization, and fuel efficiency were found to be improved.

TABLE OF CONTENTS

Chapter III: Research Methodology

Chapter IV: Presentation and Critical Discussion of Results

Chapter V: Summary Findings, Conclusions and Recommendations

LIST OF TABLES

LIST OF FIGURES

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CHAPTER I

GENERALITIES OF THE STUDY

Due to advancing globalization and interconnectivity today, technology has become important and speeds up our life. In the business environment, it allows each company's work to be easier and more comfortable. The exchange of information is faster. Therefore every organization has implemented many technologies as tools to support their work in order to get one step ahead of the competition. In the manufacturing industry, technology refers to the equipment, tools and systems used to manufacture or produce goods. Also, technology is used throughout the manufacturing process by companies, from the design of manufactured goods to the finished goods ready for sale and distribution. As a result, technology can make a significant impact in improving transportation efficiency (National Petroleum Council [NPC], 2007).

To gain a competitive advantage, nowadays many companies are relying more and more on modern technology and tools to facilitate optimal usage of transportation and delivery fleets. GPS is one of the technologies that help to improve performance in the supply chain. Therefore, the implementation of a GPS tracking system is adapted to the transportation department of the company in order to improve transportation service and efficiency.

Currently, most manufacturing companies have applied supply chain management to their operation to reduce uncertainty and enhance customer service, by getting the products to customers faster than the competitors, with lower cost. The entire manufacturing and distribution process of a company is included in the supply chain. The ultimate goal of supply chain management is to meet customer demand efficiently. To improve a manufacturing supply chain, the company should deliver products to the customer on time with the right product, at the right quantity and at the right place. Using technology in an organization can lead to improvement in its

transportation service. As a result, transportation is the base of efficiency that can bring benefits to company competitiveness if it performs well. Moreover, customer demand for timely delivery is stricter in the present day. It means that the customer's request for frequent delivery with small batches, as well as a shorter and reliable lead time (Altman 2003; Lee, Hwang, Wang, & Li, 2009). Fast and reliable delivery can create benefits to a company, such as expanded market share, lower costs and satisfied customers (Li & Lee, 1994).

1.1 Background of the Study

GPS or Global Positioning System is used as a tracking technology. The most important applications of GPS are positioning and navigation (Xu, 2007). GPS uses satellite technology and encompasses 24 satellites placed into orbit to provide an exact position on Earth any time, anywhere, in any weather. Currently, GPS is a vital component of the emerging global information infrastructure, and encouraged by the increased demand of community, commercial and scientific users. Over the past few years, many organizations use GPS vehicle tracking system in order to track and trace information about the time and position of fleet vehicles. Real-time delivery or transportation information can be provided to customers when they require it. The tracking unit keeps the data which is transmitted to a server or internet-connected computer by using a cellular modem, two way radio, or satellite. Using either web browser based tools or customized software, it allows to provide the real time data. With GPS tracking system, companies can significantly reduce operational costs, improve vehicle utilization, increase driver productivity, shorten the route and time, as well as improve customer service.

Company Profile

CVC Company[1] is a foreign investment company which is an industrial component manufacturer in Thailand. It produces plastic and sheet metal component parts, for example, sheet metal home appliances, automotive parts, electronic parts, plus

[1] CVC Company is a pseudonym.

medical and science applications, to serve both domestic and overseas customers. Approximately 30 percent of products are exported to overseas customers and the remaining percentage is shipped within the domestic area. The products are produced according to customers' drawing and design. To satisfy the different needs of each customer, CVC Company has diversified equipment and machines used in the manufacturing process, for instance, stamping machine, bending machine, punching machine, and laser cut machine. The company uses both make-to-stock and make-to-order approaches in production. Some product volumes are very small and some product volume is very big. For an order that has high volume, the customers will give a forecast or demand to the manufacturer for planning, producing and keeping in stock until the customer calls in. This type of order the company will treat as make-to-stock. Make-to-order items are usually in very small volumes but high value, which will be produced and procured after receiving a purchase order from the customer. Consequently, order cycle time is usually longer than for make-to-stock items. However, one of company's goals is emphasizing on-time product delivery.

1.2 Statement of the Problem

Over a few years, the manufacturing sector has become more and more competitive, and many companies are now facing productivity slow-down if they are not able to support a customer's demand within the specified period.

Each day, the transportation department of CVC Company receives delivery information regarding where to go, how many items will be delivered, and when they have to leave the company. The company delivers goods to customers by its own pickup trucks. The driver is responsible for picking up and delivering goods from the manufacture to the customer's site. In addition, the driver is responsible for loading and unloading their shipments. CVC is a manufacturing company which produces diversified products to serve both oversea and domestic customer. For the oversea customer, the company use the customers' shipping agent so, there are no issues regarding on-time delivery in this section since the products have been shipped out from the factory. On the other hand, there are many problems in domestic delivery,

ranging from the dispatch of goods from the warehouse until they arrive at the destination. This study will focus on the problem of running out of time that occurs during transportation to the customers due to inefficient management in the transportation department of the company. The meaning of running out of time in this case study is that the company cannot finish transporting goods within working hours. In case a customer has limited working time for receiving goods, if the driver cannot reach the customer's site within the time window he has to return the finished goods to the company, to be delivered again the next day. In addition, this problem generates excessive working overtime, as shown in Table 1.1.

Table 1.1: Percentage of Working Overtime to Available Working Hours per Week

Week	Available Working hour (hour)	Working Overtime (hour)	%OT to available working hour
Week 1	240	125.0	52.08%
Week 2	240	156.5	65.21%
Week 3	240	140.5	58.54%
Week 4	240	107.0	44.58%
Week 5	240	105.0	43.75%
Week 6	240	103.5	43.13%
Week 7	240	115.0	47.92%
Week 8	240	106.0	44.17%
Week 9	160	61.0	38.13%
Avarage %OT per week			**48.61%**

Remark: Available working hours is calculated from working hours per week multiplied by the number of drivers.

The causes of not having enough time to deliver goods which CVC Company has been experiencing while the goods are being transported, might be because the truck drivers wanders off or deviate from the original route, and spend too much time resting or sleeping. Sometimes, their traveling is interrupted by an unexpected situation that forces them to use an alternative route. These situations can generate long traveling time, as shown in Table 1.2. It also illustrates the average of Driving Time, Available Working Hours, Driving Distance and Driver Utilization per Week.

Table 1.2: The Average of Traveling Time, Driving Time, Available Working Hours, Driving Distance and Driver Utilization per Week

Week	Traveling Time (hour)	Driving Time (hour)	Available Working hours (hour)	Driving Distance (kilometer)	Driver Utilization
Week 1	255.32	122.79	240	8,086	51.16%
Week 2	253.70	126.89	240	7,949	52.87%
Week 3	82.33	101.24	240	7,309	42.18%
Week 4	221.17	107.33	240	7,630	44.72%
Week 5	275.20	68.48	240	8,968	28.53%
Week 6	244.07	113.37	240	7,065	47.24%
Week 7	220.28	121.07	240	6,391	50.44%
Week 8	228.33	107.48	240	6,946	44.78%
Week 9	72.52	47.19	160	2,145	29.49%
Average	**205.88**	**101.76**	**231.11**	**6,943**	**43.49%**

If the driver takes too much traveling time, it can cause the company increased cost of transportation, and low driver utilization, and has a direct effect on the company's reliability and reputation in the long run. Table 1.3 illustrates the average fuel consumption and fuel efficiency of CVC Company, which are the factors that have effects on transportation efficiency. Moreover, driving at high speed can cause high consumption of fuel. The more speed, the more fuel expense.

Table 1.3: Fuel Efficiency

Average	Before GPS Installation
Driving distance (km)	32,032.50
Fuel consumption (liter)	3,413.56
Fuel efficiency (km/l)	9.38

Remark: Average fuel price is 29.17 baht per liter.

In addition, a manager or leader cannot keep track of the vehicle which delivers the goods to the customer. For example, when a customer would like to know what time the goods will be arriving at their places via phone or email, employees cannot reply or respond to the customer's requirement immediately. This is because of lack of

information. The company does not have any information for tracking the drivers' status after they have left. They even do not know when the driver will come back to the company. In this situation, the transportation manager has to know where a shipment is or when it will arrive at its destination. Such information would be able to improve the utilization of the vehicle and labor, and also improve customer service.

For this reason, GPS tracking system is introduced for improving efficiency of transportation and in a timely manner. Firstly, the transport manager can monitor their staffs and make sure that their vehicle is secure. Secondly, the use of GPS tracking system can provide comprehensive reporting data regarding how long the truck was stopped at each place, and at what speed the trucks are driven. These abilities of GPS tracking system help the company to increase vehicle utilization, reduce travelling time, reduce fuel expense, increase customer service, control driver behavior and also ensure safety for drivers and vehicles. However, this study proposes to install GPS tracking system into vehicles for transportation, to solve the problems in this manufacturing company. Therefore, the focus question for this study is ***"Does the implementation of GPS tracking system improve the transportation efficiency of CVC Company?"***

1.3 Research Objectives

In order to achieve this implementation plan of using GPS tracking system, the following are objectives to be achieved:

1 To understand the application of GPS tracking system.

2 To develop a plan to implement GPS tracking system for the transportation department of an industrial component manufacturing company.

3 To verify possible outcomes of the implementation of GPS tracking system.

1.4 Scope of the Research

The study focuses on a case study of the transportation department in an industrial component manufacturer which has a plan to implement GPS tracking system. Delay or late delivery due to running out of time is the point. This study concentrates on managing and improving the transportation efficiency while the goods are being delivered to the domestic customer. Therefore, on-time delivery in this study is defined as the arrival of delivery by transportation of goods to the customer terminal within a committed time, regardless other factors such as quality. The historical data related to transportation or delivery will be gathered from the transportation department. The amounts for expenses used in this paper are only approximate figures due to limited information disclosure by the company.

1.5 Limitations of Research

In every organization, there are many factors that have an impact on transportation efficiency which will not be included or considered in this study, such as a routing network. With differences in organizational structure and management of manufacturing companies, the results of this study may not be relevant to other companies.

1.6 Significance of the Study

The expected result of this study will be beneficial to CVC Company, a manufacturing company, in improving the efficiency of transportation after GPS tracking system implementation. A systematic and effective transportation management within the organization is established, and customers would benefit from having a trustworthy supplier to do business with. Implementing GPS tracking system will help the company to reduce traveling time, reduce fuel expense, increase driver productivity and increase vehicle utilization. In addition, it will enable the company to achieve its goal which is reliable on-time product delivery. Moreover, efficiency of transportation can lead to reducing costs throughout the supply chain.

1.7 Definition of Terms

Antenna	Antenna or aerial is an electrical device which converts electric currents into radio waves, and radio waves into electric currents (Kaplan & Hegarty, 2006).
Driver Utilization	The percentage of time that a driver spends on driving during transportation of goods to the customers (MacAdam, 2003).
Fuel Efficiency	It is a ratio of distance travelled per fuel consumption unit, and is expressed in kilometer per liter (Small & Dender, 2007).
GPS (Global Positioning System)	A satellite-based navigation system. It was launched through 24 satellites placed into orbit of the earth by the U.S. Department of Defense (Kaplan & Hegarty, 2006).
GPS Tracking System	Consists of three components, which are GPS tracker, Server and user interface. The system used to track position, time and speed of the vehicle (Kaplan & Hegarty, 2006).
Navigation	Is about the controlling and monitoring of movable objectives in order to find their time and position (Kaplan & Hegarty, 2006).
Telematics	It is any integrated use of information and telecommunication in conveying information over the networks efficiently; also known as ICT (Information and Communications Technology) (Quddus, Ochieng, Zhao & Noland, 2003).
Transportation efficiency	It is the state of quality or grade of being efficient in transportation. It brings about the result that is wanted, with the least waste of time, effort.

	Effective operation as measured by a comparison of transportation with cost (as in energy, time, and money), degree of being efficient; not wasteful. It is whether certain investments can under the given circumstances provide for the best utilization of the resources (Markovits-Somogyi, Bokor, & Tibenszkyne Forika, 2010).
Traveling time	The time for one round trip which a driver spends on transporting goods to the customers, including stop and waiting as well as actual travel (Schöbel & Scholl, 2006).
User interface	It is the space where interaction between humans and machines occurs, including hardware (physical) and software (logical) components (Kaplan & Hegarty, 2006).

CHAPTER II

REVIEW OF RELATED LITERATURE

A variety of literature which is relevant to the topic of this study is reviewed in this chapter. It consists of five main sections which are related to the implementation of GPS tracking system and improvement of transportation efficiency. The first section explains what GPS is and how it works. The second section is the application of GPS, followed by the third section which is GPS tracking system application. The fourth section describes the three components of a single system. The last section gives an explanation of the efficiency of transportation.

2.1 Global Positioning System (GPS)

Global Positioning System also known as GPS is a system of Satellites surrounding the earth. It is widely recognized as a vital component of the emerging global information infrastructure. GPS comprises 24 satellites which orbit twice a day above the earth and transmit signal information to the receivers on the ground. GPS receivers take this information and use triangulation to calculate the exact location and time of the user. Basically, the GPS receiver compares the time a signal was transmitted by a satellite with the time it was received. The variation of time tells the distance of the satellite to the GPS receiver. Now, with distance measurements from the satellites, the receiver can determine the user's location or position and display it on the unit's electronic map. There are two public Global Positioning Systems (GPS systems) which are NAVSTAR and GLONASS. NAVSTAR, which stands for navigation system with timing and ranging global positioning system (Chi, 2004), is a system owned by the United States. It is managed by the NAVSTAR GPS Joint Program Office located at Los Angeles Air Force Base. GLONASS is a system owned by the Russian Federation. All global positioning system satellites transmit accurate signals to indicate the three dimensions of velocity, time and position.

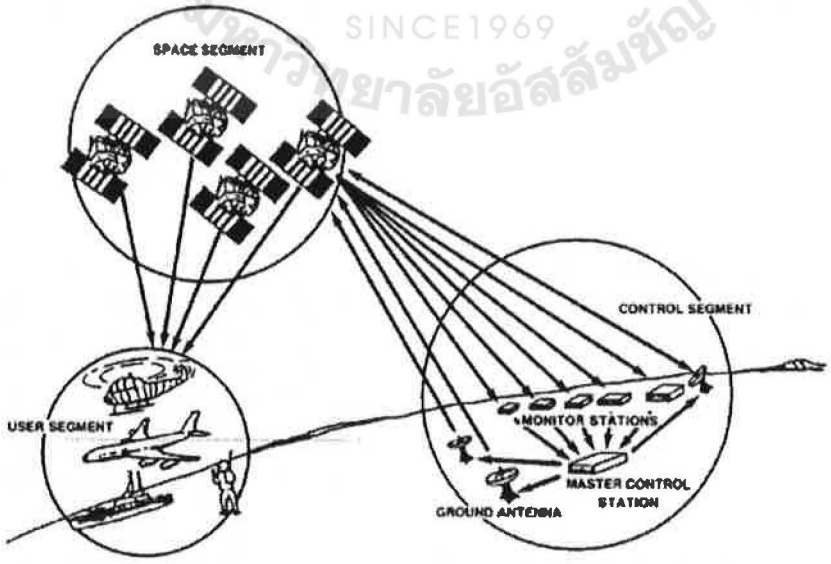
GPS is composed of three main segments, which are user, space and control, as described below and shown in Figure 2.1.

1) User Segment consists of receivers, processors and antennas that authorize land, airborne and sea operators to receive the information or data transmitted from GPS satellite, and make an exact calculation of their speed, position and time.

2) Space Segment includes 24 operational satellites in six circular orbits, which are 20,200 km above the earth and inclined at 55 degrees with a rotation period of 12 hours around the earth. The data of position and time is broadcasted throughout the world by all satellites.

3) Control Segment consists of a master control station, ground antennas and monitor stations. The monitor stations keep track of all GPS satellites and collect information from the satellite broadcasts. The monitor stations send the collected information to the master control station that computes precise satellite orbits.

Figure 2.1: Navstar GPS Major Segments



Source: Navstar GPS User Equipment Introduction (n.d., pp.1-1)

The previous research provided important discussions. For instance, Hafberg (1995) studied the concepts and techniques to combine GIS, GPS, and other digital communication technologies to locate the position and speed of vehicles. His study emphasized the importance of the connection with the central monitoring system. Zito, D'este, and Taylor (1995) discovered the application of GPS technologies for constructing vehicle-highway control systems. Their paper discussed the use of GPS for receiving information regarding the place location, travel direction, and speed of vehicles. Weigel and Cao (1999) studied the application of GIS and OR techniques to the problems of technician-dispatching and home-delivery of Sears. Similar problems are analyzed in the practice of home delivery business. For instance, Jung, Lee, and Chun (2006) studied the implementation of GPS and related technologies in parcel delivery service. They analyzed a GIS and GPS intelligent system for parcel collection and delivery in Korea. Imielinski and Navas (1999) described the technical development of GPS and its important usage for geographic data collection. Their research studied the problem of global positioning system based on addressing vehicle routing, and resource discovery. Derekenaris, Garofalakis, Makris, Prentzas, Sioutas and Tsakalidis (2001) investigated a system that integrates GIS and GPS technologies for the effective management of ambulances and emergency incident handling. Other research on GPS technologies also focuses on a variety of situations, including vehicle delivery and routing (Keenan, 1998), emergency management of fire trucks and ambulances (Derekenaris et al., 2001), as well as construction and engineering management (Li, Kong, Pang, Shi, & Yu 2003).

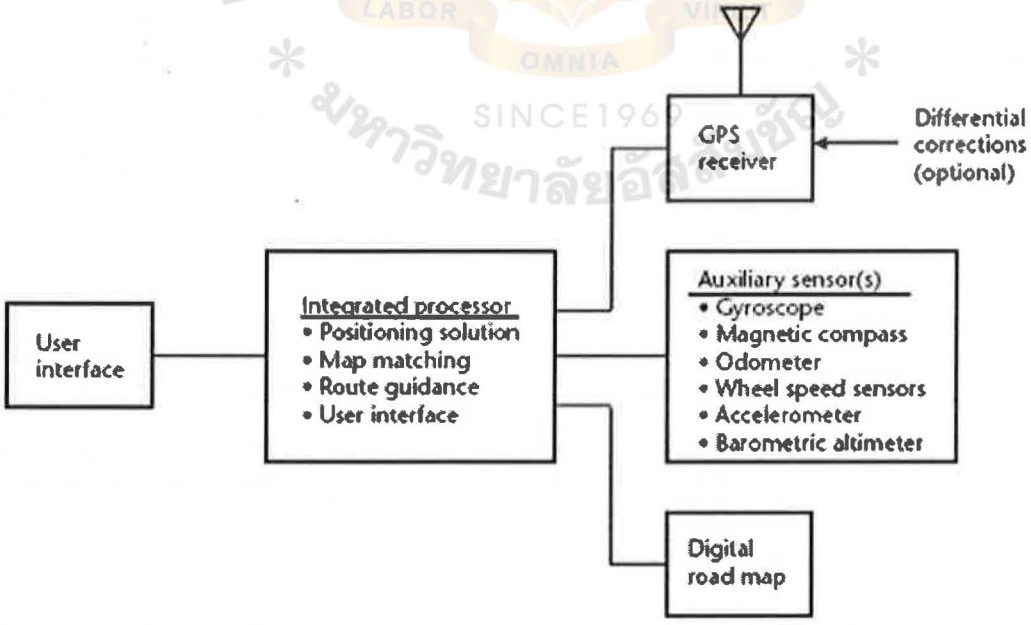
2.2 GPS Applications

GPS has a wide range of applications. It is used in the air, on land and at sea. The most common airborne applications are for navigation by general aviation and commercial aircraft. At sea, GPS is also used for navigation by commercial fishermen, recreational boaters, and professional mariners. Land-based applications are more varied. Using GPS on land is for knowing its position information and precision timing capability. By the early 1990s, due to advance in GPS technology

and wide use in automotive environments, the cost of GPS receivers had decreased dramatically (Kaplan & Hegarty, 2006). GPS is now used in transport systems for locating vehicles, tracking vehicles, and providing navigation assistance to drivers.

A vehicle navigation system is intended for use in automobiles. The purpose of vehicle navigation systems is quite simply to help a driver get to a destination. The application of a generic vehicle system is illustrated in Figure 2.2. Major components include a user interface to enter a destination, a GPS receiver to determine the absolute position of the vehicle, possible auxiliary sensors for augmenting the positioning solution, access to a digital map database for planning routes, and determining maneuvers to present the directions to the driver by voice, graphics, or both via the user interface. Access to digital map data is important for route planning and improving the positioning if it available in the vehicle. GPS is used for positioning in virtually every vehicle navigation system on the market. Differential GPS corrections may be provided and applied to improve the positioning accuracy of the solution.

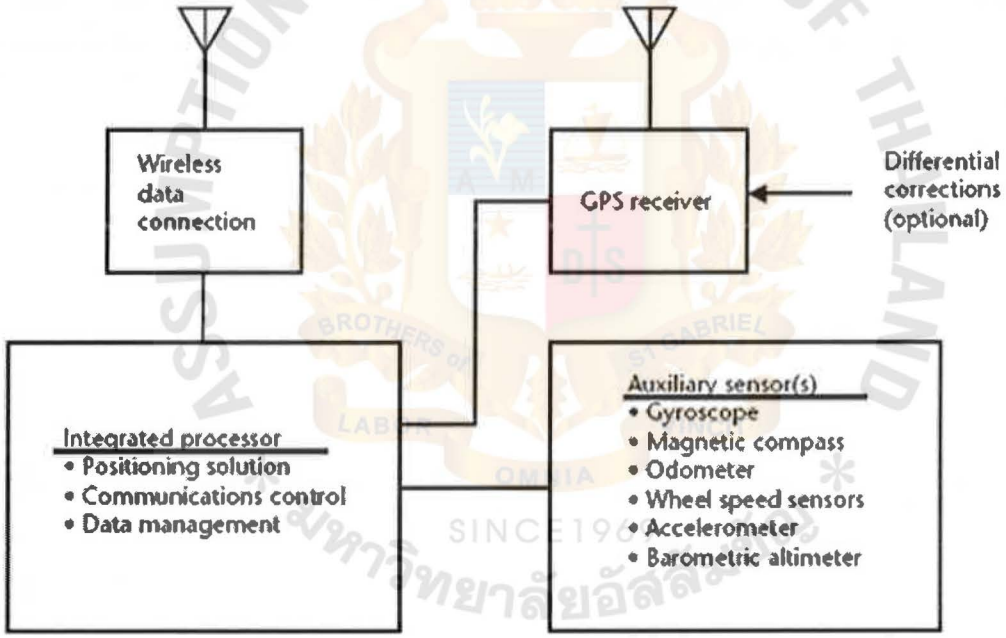
Figure 2.2: Generic vehicle navigation system architecture.



Source: Kaplan & Hegarty (2006, p.492)

In vehicle tracking system applications, the time and location of the vehicle is determined and then sent via wireless data connection to a centralized monitoring facility or fleet dispatcher. A typical vehicle tracking system architecture is shown in Figure 2.3. Like the navigation system, the tracking system has a GPS receiver, auxiliary sensors, and a computer processor to control the components and calculate the optimized position solution. In addition, there is a wireless data radio for communicating the vehicle position data and possible status to the central monitor. At the central monitor, the vehicle position and time may be displayed on a digital map.

Figure 2.3: Generic vehicle tracking system architecture.

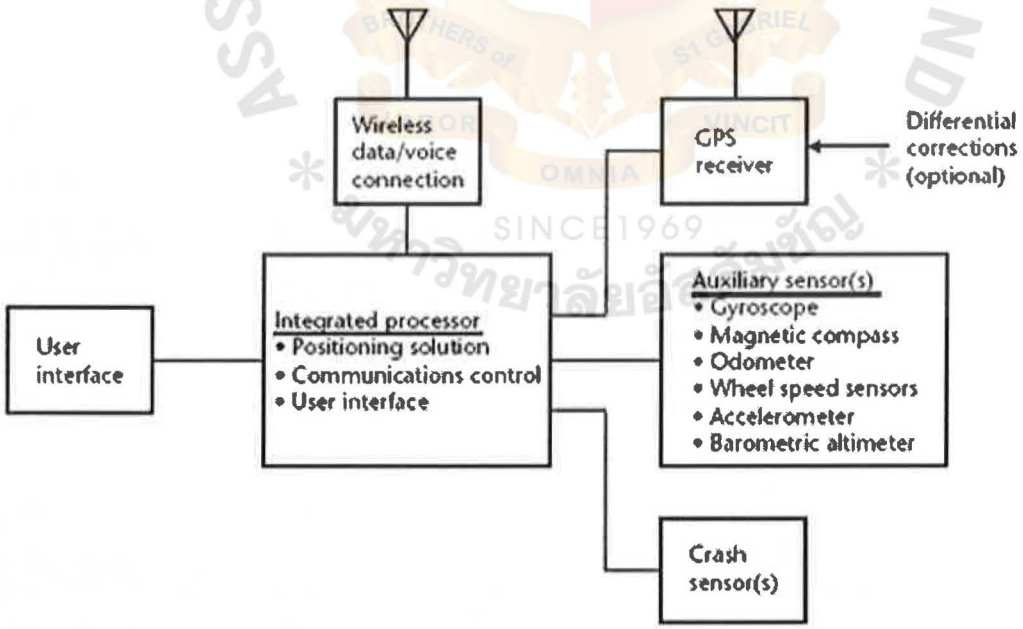


Source: Kaplan & Hegarty (2006, p 492)

There are many wireless technologies that may be used as the data radio, including cellular modems, cellular packet data, two-way paging, satellite links, and private data networks. Enterprises that own or operate fleets of vehicles (e.g., taxis, delivery trucks, or service vehicles) use vehicle tracking systems to monitor the usage of the vehicles and improve efficiency in transportation and logistics. Public safety departments (e.g., police, fire, or ambulance) use vehicle tracking to reduce call response time and to locate workers in the case of distress calls. Individual vehicles

can be located in emergency situations using GPS and wireless communications. These emergency messaging systems, also known as telematics systems, are offered by many automobile manufacturers today. A generic emergency messaging system architecture is shown in Figure 2.4. Typically, these systems use a cellular phone for wireless data communications because of the dual-purpose voice and data capabilities, extensive coverage throughout most developed countries, and relative low cost. These devices are connected to vehicle systems or to the vehicle bus and can notify a service provider automatically when an air bag is deployed or some other crash sensor is triggered. The user interface includes one or more buttons to activate the system, a hands-free voice call capability, and possibly a display to indicate status. The GPS position of the vehicle is sent via the cellular phone so that emergency services or other assistance can be sent to the exact location of the vehicle. These devices are also used for crash notification, roadside assistance, theft tracking, and direction assistance.

Figure 2.4: Generic emergency messaging system architecture.



Source: Kaplan & Hegarty (2006, p.493)

2.3 GPS Tracking System

There are two types of GPS tracking system (www.spyassociatesblog.com). The first is a passive GPS tracking system. It is one way satellite communication and used when the real time data is not unnecessary but records are needed to maintain it. The second is an active GPS tracking system which provides real time data wherever it is deployed through a GPS network. Most industries, businesses and personal users have increasing interest in an active GPS tracking system, such as a vehicle tracking system. However, GPS can become part of a very effective tracking technology when it is combined with a wireless communications technology such as a mobile phone. The implementation of GPS tracking system is employed in different fields such as fleet management, pets, cargo, and other movable assets.

A GPS Vehicle Tracking system provides important information to ensure safe and faster on-time delivery which is able to reduce problems commonly associated with transporting goods. It allows the company to keep their updated information about location of deliveries and monitor the drivers. Since it has ability to measure idle time and speed, calculate distance and record stop location, it is easier for managers to keep track and control their vehicles from the office. Moreover, using a vehicle tracking system enables managers to predict the time of arrival accurately, eliminate unauthorized vehicle usage, and give a notification alert when a driver speeds or deviates from the designated route, including provided safety and security assistance for the drivers or vehicle breakdown.

According to previous research, Holland (2008) has discovered that the use of GPS vehicle tracking system has been increasing because of many reasons, as follows;

1) It was observed that the cost of a vehicle fleet can be reduced because GPS tracking system can identify excessive speed, irregular vehicle use, hard braking and general vehicle wear and tear.

2) Companies see significant increases in employee productivity. With GPS it can identify excessive resting time, time spent in delivering goods to customers, and even the use of company vehicles for personal use. This can lead to improvement in working hour efficiency.

3) GPS tracking systems are able to improve customer service when integrated with a customer relationship management program. For examples, the company can tell the customer how far away the delivering goods are, and give accurate arrival time estimates.

4) GPS tracking system helps to reduce overheads in several ways. These include identifying underutilized vehicles, as well as evaluating unreliable employees who break the company's rules.

5) It facilitates managers to retrieve transporting information, managing through their real-time reports and utilizing the mapping features of GPS tracking platforms to give a common operating picture of all the company's assets.

6) After implementation of a GPS tracking system, businesses are seeing very quick return on investment. ROI is usually within a six to twelve month time-frame, after which the system has paid for itself and actually begins to contribute to increasing the bottom line finances.

2.4 Three Components of a single set of GPS tracking system

2.4.1 GPS tracking device or GPS tracker: Olano (2007) explained that it receives the information of location and then transfer it to a software application. GPS tracker is usually a small box made from metal or plastic that needs at least one antenna to enable the data transmission module. Figure 2.5 illustrates examples of GPS trackers.

2.4.2 GPS tracking server: The responsibilities of a tracking server are receiving data from the GPS device or tracker, keeping it, and sending this information to the user when it is required.

2.4.3 User interface and software application: The UI is used to access information, illustrate vehicle data, and extract important details. People use it to interact with computers or equipment. The software application integrates the various technology and components into a highly capable and user friendly system and interface. It presents the data recollected by the GPS Tracker in several formats including maps and reports. The effective system must be capable of generating routing and reports that can be used to manage a fleet for the users.

Figure 2.5: Examples of GPS Tracker

2.5 Transportation Efficiency

The previous studies of transportation efficiency could be defined in various perspectives. Different group of interests and different system objectives will all lead to different comprehensions and values to transportation efficiency (Yuan, n.d.).

Hence, the definition of efficiency was described in various perspectives as well. Efficiency means the comparison of what is actually produced or performed with what can be achieved with the same consumption of resources such as money, time, and labor. It is one dimension of performance as an internal standard (Kaplan & Atkinson, 2003). Dobak (2006) said that efficiency is the capability of a company to realize its stated objectives, and to use its available resources cost-effectively. Webster's Dictionary also defines efficiency in a similar way, according to which efficiency is "1) the ability to produce a desired effect, product, etc. with a minimum of effort, expense or waste; a quality or fact of being efficient 2) the ratio of effective work to the energy expended in producing it, as of a machine; output divided by input". The same view is shared by Markovits-Somogyi, Bokor, and Forika (2010) who defined it as the ratio of the products, services and other results produced during a given activity and the resources utilized for their production. Based on a transportation perspective, the definition of efficiency given by O'Sullivan (1980) defines efficiency as a matter of meeting the needs for movement at the least social cost. Another definition from Markovits-Somogyi (2010) explained that a transport firm is efficient if and only if none of its outputs can be increased without increasing one or more of its inputs. Sullivan, Aultman-Hall, and Watts (2010) defined transportation efficiency as the maximization of services at the lowest possible cost .Many researchers take transportation efficiency to be synonymous with a specific improvement measure, such as increase in the vehicle occupancy rate (Moudon et al, 2005)

Transportation is a vital element in logistics, which connects each activity in the logistics chain from manufacturing until delivery to the customers. As a result of efficient transportation, efficient logistics could be provided including reducing operation cost, and promoting service quality because it can create value in the supply chain. From the previous study, there are many factors that impact on efficiency of transportation, such as flexibility of administration, personnel capability, and collaboration (Hugos & Thomas, 2006). In addition, information is also considered as a factor which includes information technology, with updated and sufficient information (Closs, Goldsby, & Clinton, 1997). Leybovich (2010) explained that

advanced technology is one factor that can improve the efficiency of transporting goods by reducing cost. As a result, transportation plays a major role in doing business across the industrial sector. Especially, unnecessary energy consumption due to inefficient routes or business processes leads to increase expenditure.

CHAPTER III

RESEARCH METHODOLOGY

This chapter aims to describe the methods and tools employed for improving efficiency of transportation. The research emphasizes discovering the effects of GPS tracking system on the transportation and product delivery service of an industrial component manufacturing company. This chapter consists of six sections. The first section is required data which should be collected. The second section is the method used to collect data in order to understand the problem thoroughly. The third section copes with problem analysis. The fourth section describes the GPS implementation plan followed by possible outcomes of the GPS implementation in the fifth section. The conclusion is explained in the last section.

3.1 Required Data

The required data in this study consist of both qualitative and quantitative data. The point of destination in daily shipments that represents the route is needed. The record of approximate distance in a whole month and the historical fuel expenses in each month will be gathered. Moreover, working hours, time in and time out of drivers, are recorded. The loading and unloading time at the customer's locations is estimated from interviewing drivers.

3.2 Data Collection

A key strength of the case study method involves using multiple sources and techniques in the data collection process. As part of this process, the following methods are carried out;

3.2.1 In-depth interview

To understand the cause of problem, the manager and drivers in transportation department are interviewed. These interviews provide significant information regarding transportation of goods, the impact of not having enough time to deliver the products, the causes of running out of time problem, from the viewpoint of manager and drivers, and also managers' perspectives on future developments. However, the interviews of manager and driver are conducted separately. Each interview took approximate 20-30 minutes. From the interview of managers, transporting or delivering goods cannot be tracked data or information of the time and position of drivers. The way managers communicate with the driver is via phone call and sometimes a driver could not be reached. Using the mobile phone of a driver while driving, can cause an accident. In addition, the estimated time of arrival is quite inaccurate and it causes customer complaints. Driver efficiency and speed of vehicle have an effect on on-time delivery. Drivers do their work slowly, because no one monitors them. This problem can lead to running out of time. From the driver's perspective, the congestion at the customer's receiving department cause them to delay the next shipment. Some drivers take a familiar route to travel which is not the specified path. Sometimes the driver was mandated to pick up some parts from a vendor urgently, and for this reason the driver had to wander off the route.

3.2.2 Documentation review

All related documents in the company have to be reviewed in order to realize how the work operation. For example, schedule plans or truck assignment sheets of the transportation department, driver's daily report, invoice of fuel expense each month.

3.2.3 Observation

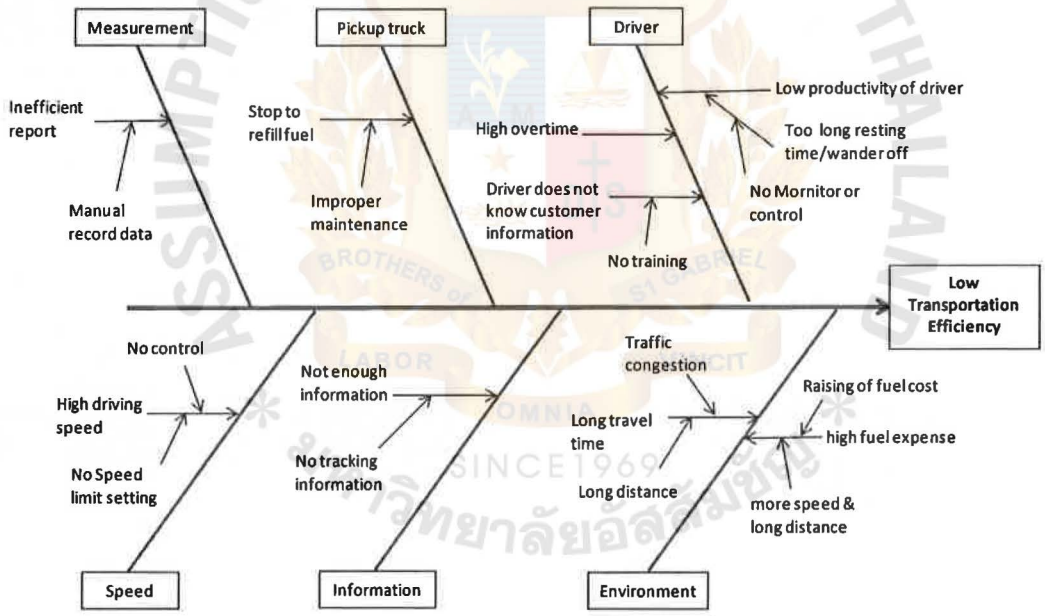
The observation will be carried out in order to ascertain the 'time' used in each operational activity, such as the time it takes to load and unload the goods into the pickup truck, travelling time from the company to the customer, how many customers

are met each day, and how many trips per day. The data from observation is able to be used to analyze the situation of CVC Company.

3.3 Problem Analysis

There are many elements and factors that have an impact on the efficiency of transportation. After the data collection process is conducted, the problems of CVC Company are analyzed and the root causes identified in a cause-and-effect diagram, as illustrated in Figure 3.1

Figure 3.1: Cause and Effect Diagrams



The effect of low transport efficiency should be improved after implementation of a GPS tracking system. If these causes could be solved, such as lower fuel expense, high driver productivity, and short traveling time, it would indicate that the efficiency of transportation is improved. The explanations of each possible factor derived from brainstorming are now described.

3.3.1 Driver

Each driver is an important factor that impacts transportation efficiency. Their productivity is quite low. This primary cause can be influenced by inferior causes such as overlong resting time, or the driver might wander off during transportation of goods. As a result, there is no monitoring or control of drivers. Furthermore, insufficient information regarding customer procedures can waste a driver's time. Also high overtime payments represent low transportation efficiency.

3.3.2 Pickup Truck

When the vehicle has to stop in order to refill its fuel, it is a non-value added activity and wastes time in transporting goods to a customer. This might be caused by improper maintenance of the vehicle.

3.3.3 Measurement

Before implementation of a GPS tracking system, the staff has to manually input data of the transportation department. Therefore data entry error or inaccurate data might occur.

3.3.4 Speed

The primary cause of speed is driving at a speed beyond its usual efficiency. It can increase fuel consumption, and fuel efficiency will decrease. Also without a speed limitation on drivers, and without any monitoring of their driving behavior, drivers will not be much concerned with the importance of driving at excessive speed. They will drive as fast as possible if they think that safe.

3.3.5 Information

There is insufficient information, such as the route, map, and the estimated time take to the destination, because there is no tracked historical data. This information can lead to faster delivery or transportation of goods.

3.3.6 Environment

High fuel expense is related to speed: driving at excessive speed can cause high fuel consumption. Another factor in the environment theme is travel time, as the company experiences long travel time. In this study, travel time is calculated as the difference between time of departure and time of arrival in one round trip, including driving time, driver's resting time, extra unnecessary stops by the driver, and loading and unloading time at the customer site. However, traffic congestion and fuel cost are the secondary causes that influence fuel expense, but both factors are beyond the control of this study.

3.4 GPS Implementation Plan

The determination of problem analysis elicited the root causes which should receive more attention. Then, a GPS tracking system is applied to correct the causes of the problems in order to improve efficiency of transportation. The implementation plan for a GPS tracking system begins with the selection of the GPS tracking system devices. With various GPS trackers on the market, the most suitable device will be selected for the company. Also a cost comparison of different types of GPS is one determinant that helps in the selection of the most efficient and effective GPS tracking system. Therefore, an essential meeting and discussion is conducted with members. Once the suitable GPS tracking system device is selected, the next steps of implementation plan are identify the related department, a brief description of each major task is required (such as what the task will accomplish, resources required, the budget, etc.) and the schedule of each task is provided.

3.5 Possible Outcomes of the GPS Implementation

In this section, the study will present the research findings and analysis with respect to the application of a GPS tracking system and the impact on transportation efficiency. The expected results after implementation will be compared with the actual data. The advantages or benefits resulting from the GPS tracking system will be discussed. The data can be calculated by using Excel spreadsheet. It is simple to use as a tool for comparisons data, saves time and converts to chart or diagram.

3.6 Summary

This chapter explained the method and techniques employed in this research study. Both quantitative and qualitative data is gathered to understand the root causes, problems, and effects of this study. In-depth interview, observation and document review are the methods used to collect data. A plan of implementation is conducted. All required data is used to analyze the problems which should be solved by a GPS tracking system in order to improve transportation efficiency.

CHAPTER IV

PRESENTATION AND CRITICAL DISCUSSION OF RESULTS

This chapter presents the key findings after implementation of a GPS tracking system, critical analysis, and discussion of the results. It is divided into four sections. The first section explains the transportation efficiency measurement. The second section is the situation analysis prior to implementation of GPS. The third section elaborates the implementation of a GPS tracking system according to the implementation plan in chapter III. The fourth section shows the results of the GPS tracking system implementation and the improvement of transportation efficiency.

4.1 Transportation Efficiency Measurement

This study uses a "before and after" comparison application to evaluate the transportation efficiency improvement. CVC Company's transportation data was collected to determine the improvement of the transportation efficiency after the implementation of a GPS tracking system. With a GPS tracking system, the researcher is able to measure transportation efficiency in terms of time and speed.

Time efficiency is the percentage of available time that the company actually utilized. In terms of time efficiency, working overtime and long traveling time are undesirable and need to be minimized in order to accomplish the improvements in transportation efficiency. Traveling time is the time for one round trip which a driver spends on transporting goods to the customers including stop, waiting, and actual travel. Both stop and waiting are a waste of time. To minimize drivers working overtime, driver utilization should be increased. Also to shorten traveling time, non-value added activities should be eliminated. Driver utilization is determined as the percentage of time available that the driver actually drives. The time available is the working hours in a period of time. The time used is the driving time that the driver spends on the road.

Since speed could not be measured prior to the GPS installation, speed efficiency is explained in terms of fuel efficiency. A higher driving speed leads to more fuel consumption and fuel expense consequently. Fuel efficiency is calculated from total travel distance divided by the fuel consumption unit. It is expected to increase in order to improve transportation efficiency.

4.2 Situation Analysis Prior to the GPS Implementation

After reviewing documents and observation, the researcher recognized that the company has seven pickup trucks and five drivers for daily transportation or delivery of goods. The pickup trucks are not assigned to any specific drivers and can be used by every driver. The drivers work eight hours a day from 8.00 AM to 17.00 PM, six days a week from Monday to Saturday. If the driver needs to work after 17.00 PM, the excess hours are counted as overtime and will be paid an additional 50 percent of normal wages for those hours. Every morning each driver is assigned to the destination by their supervisor.

The company produces make-to-stock and make-to-order products which resulted in the diversity of the products. With many product types, the complexity in loading onto the vehicle increased, and additional skillful staff for loading goods within the manufacturer were required. A person prepares the goods for the drivers and loads them onto available pickup truck for delivery. When the drivers come back with the empty pickup trucks, the trucks will be prepared for the next transportation. Time and distance of each trip are also recorded by the factory's security guard before the driver leaves (as shows in Table 4.1). This data was collected from June 1st to July 31st 2011, a total of 61 days. The data was used to calculate average traveling time and driving distance on a weekly basis. Driving distance was gathered from the difference of distance (kilometers) from departure to arrival. The traveling time (minutes) was calculated from time of arrival minus time of departure.

Table 4.1: An Example of Driver Daily Log in June 2011

Month	Date	Truck No.	Time of Departure	Time of Arrival	Travel Time (Minutes)	Driving Distance (Kilometers)
Jun	1	PT-006	6:10	7:50	100	62
Jun	1	PT-004	6:13	7:45	92	71
Jun	1	PT-006	8:10	9:05	55	38
Jun	1	PT-005	10:00	20:00	600	265
Jun	1	PT-001	10:05	16:40	395	272
Jun	1	PT-006	14:25	16:07	102	8
Jun	1	PT-007	14:45	21:10	385	101
Jun	1	PT-002	16:30	17:15	45	7
Jun	1	PT-006	17:10	19:27	137	74
Jun	1	PT-002	20:10	21:35	85	80
Jun	1	PT-006	20:08	21:30	82	61
Jun	1	PT-002	21:55	22:30	35	7
Jun	1	PT-004	2:30	3:00	30	7
Jun	2	PT-006	6:00	7:40	100	62
Jun	2	PT-004	6:05	7:50	105	71
Jun	2	PT-006	8:10	9:20	70	38
Jun	2	PT-002	9:00	14:00	300	95
Jun	--	---	---	---	---	---
Jun	--	---	---	---	---	---
Jun	--	---	---	---	---	---
Jun	--	---	---	---	---	---
Jun	30	PT-002	14:20	17:55	215	98
Jun	30	PT-007	16:00	17:10	70	8
Jun	30	PT-006	17:10	19:20	130	74
Jun	30	PT-003	17:05	22:00	295	185
Jun	30	PT-006	20:08	22:00	112	15
Jun	30	PT-004	20:08	21:00	52	55
Jun	30	PT-004	2:05	2:40	35	7
Average travel time and distance per day					**2,466**	**1,296**

Source: CVC Company

On average, total traveling time and distance per day in June 2011 was 2,466 minutes and 1,296 kilometers respectively. This data was used as a baseline to compare with data after the implementation.

Based on time efficiency prior to the implementation, the average percentage of working overtime per week was 48.61 percent of available working time. High working overtime could lead to higher operational cost of the company. If working overtime after the GPS implementation reduces, it means that transportation efficiency has improved. The next variable which the company could improve is driver utilization. The driver utilization rate was only 43.49 percent, which indicated that the company had a low driver utilization rate. The researcher believes that the implementation of a GPS tracking system could encourage the drivers to concentrate and pay more attention to their work.

Another dimension of transportation efficiency measurement was speed. As mentioned earlier, speed could not be collected prior to the GPS implementation. Therefore, this term of efficiency was measured in terms of fuel efficiency. It is believed that driving at high speed can raise fuel consumption. The average fuel efficiency was 9.38 kilometers per liter. It was quite low efficiency because the company had no limited-speed policy for the drivers. This variable was expected to increase in order to verify that transportation efficiency had improved.

4.3 GPS Tracking System Implementation

In this section, GPS tracking system is explored. There are two major types of GPS tracking system available in the market, passive and active GPS tracking systems. The first step is to understand the advantages and disadvantages of each type in order to select the right one that is suitable for the company. Table 4.2 summarized the comparison details of active and passive device. The passive device cannot provide real time information as it happens, but it can provide recorded travel log data by downloading it from the device. To use the passive device, a computer software package is required. On the other hand, the active device is able to track real time information which allows the managers to easily monitor and control the operations. In order to track the vehicle's time, speed, and position, the trackers must have internet access. However, one drawback of the active device is that it costs more than the passive device. Active device users have to pay a monthly service charge to the

satellite-based GPS service provider in order to keep track of the real-time data, while the passive device user does not need to pay this cost. Even though the active device is more expensive than the passive device, it is more popular than the passive one as it is more user friendly.

Table 4.2: Comparison of the Active and Passive GPS Devices

GPS tracking system	Active	Passive
Data provide	Real time data	Recorded data
Cost	Expensive	Low
Memory	Unlimited	Limit
Internet connection	Important	Not necessary
GPRS module	Built-In GPRS	Not necessary
Software package	No	Need
Service Charge	Yes	No

After understanding the concept of each type, CVC Company decided to select the active GPS device because it is more suitable for the company. It could be used to solve the problem of low efficiency in goods transportation. Because of its real-time information, the company would be able to respond to the customer's requirement regarding quick delivery. Also, manager can monitor the drivers easily, and it does not take time when a report is needed.

Then, the company made contact with several companies who provide GPS tracking technology, and thorough evaluated them. In addition, there are several models of GPS trackers with a broad range of features. The following list contains key features of a GPS tracking system that the company needed and used as criteria, with the price, for selecting devices.

1) Web based Application was required because it does not need installed software for login and is able to access real time data which is sent to a computer via internet. It means that every computer can be used to access data everywhere that has an internet signal.

2) Tracking real time information of speed, time and location for monitoring and controlling.

3) Generate comprehensive reports to the company for checking and analysis.

Before installation of this tracking system, each task or activity of involved departments was defined and allocated to personnel in the preparation meeting. For example, Purchasing Department had to negotiate the price of a GPS tracking system, Information Technology Department needed to be ready to support the system, Marketing Department had to prepare a customer database to enter into the system, and all involved staffs were trained to understand how to utilize GPS tracking system.

Afterwards, the implementation was conducted by using a GPS tracking system. The data was collected, and operation began from August 1st 2011 until September 30th 2011, totalling 61 days. GPS tracking devices were attached to seven pickup trucks that the company has been using in transporting goods to customers. One set of active GPS devices cost the company 6,500 baht per month, including a monthly service charge for the tracking system. Consequently, the company had to pay a total of 45,500 baht per month for seven pickup trucks. Once GPS tracking devices were installed, the database of each vehicle was input, and customer locations were pinpointed on a Google map, then collected data was ready to be recorded in the system. Consequently the company can investigate the results to find out whether the implemented GPS tracking system can actually improve transportation efficiency for the company, as expected.

4.4 Results of GPS Tracking System Implementation

To evaluate the results of GPS tracking system implementation, the data was collected over 61 days, from August 1st to September 30th 2011. After implementation, the company could measure the time that the drivers actually departed and arrived at the manufacturer during the day. In addition location of drivers could be tracked whenever the company needed to know. Drivers also understood that they were

monitored by their manager or supervisor while they out to transporting goods to the customers.

4.4.1 Analysis of Working Overtime

Table 4.3 Comparison of the Percentage of Working Overtime to Available Working Hours

Before GPS Installation				After GPS Installation			
Week	Available Working hours (hour)	Working Overtime (hour)	%OT to available working hour	Week	Available Working hours (hour)	Working Overtime (hour)	%OT to available working hour
1	240	125.0	52.08%	1	240	82.0	34.17%
2	240	156.5	65.21%	2	200	65.0	32.50%
3	240	140.5	58.54%	3	240	138.0	57.50%
4	240	107.0	44.58%	4	240	123.0	51.25%
5	240	105.0	43.75%	5	240	105.0	43.75%
6	240	103.5	43.13%	6	240	133.0	55.42%
7	240	115.0	47.92%	7	240	120.5	50.21%
8	240	106.0	44.17%	8	240	134.5	56.04%
9	160	61.0	38.13%	9	200	40.0	20.00%
Average %OT per week			**48.61%**	**Average %OT per week**			**44.54%**

Remark: Available working hours is calculated from working hours per week multiplied by the number of drivers.

The data in Table 4.3 explains transportation efficiency in terms of overtime working. It was gathered from the Human Resource Department. Before GPS devices were installed, drivers had to write down their working overtime in an overtime request form at the end of the day, sent to their supervisor for approval, without any information for verification. Available working hours were calculated from the average working hours per week multiplied by the number of working days in a week. It can be seen that after GPS installation, the percentage of working overtime to available working hours reduced from 48.61 percent to 44.54 percent. As a result, the drivers recognized that they were monitored, so they perceived that they should complete their jobs on time and could not spend too much time on their stopover.

Also, accurate arrival and departure times were reported by the GPS tracking system. When the drivers request overtime payment, their manager is able to check times in the GPS tracking system for approval. Consequently, the company experienced a positive change in driver behavior. Nevertheless, After GPS installation the percentage of working overtime in week 4, week 6, week 7 and week 8 were not reduced. There are other factors which cannot be controlled in this study, for example delay in the production department, and there were a lot of orders from customers in these weeks.

4.4.2 Analysis of Driver Utilization and Traveling Time

Table 4.4: Comparison of Driver Utilization and Traveling Time

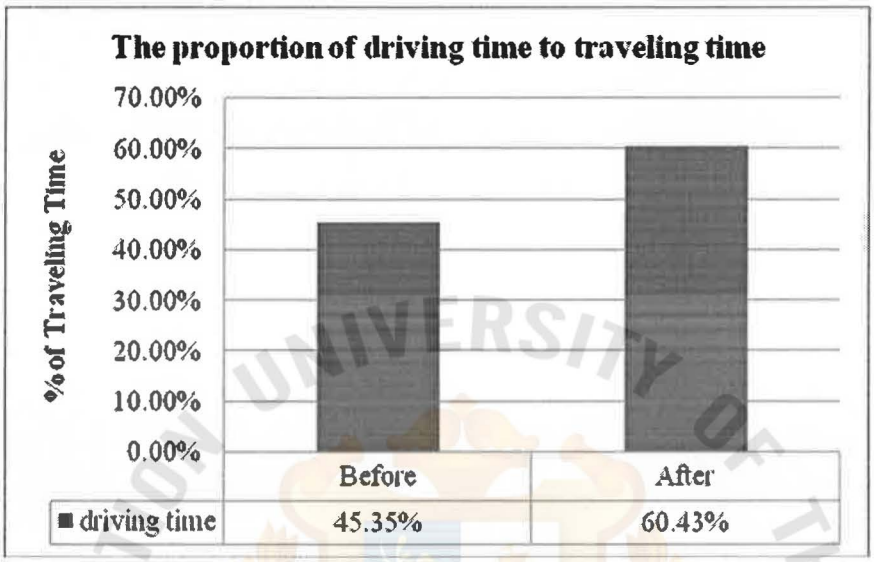
	Before GPS Installation				After GPS Installation			
Week	Travel Time (hour)	Driving Time (hour)	Available Working hour (hour)	Driver Utilization	Travel Time (hour)	Driving Time (hour)	Available Working hour (hour)	Driver Utilization
1	255.32	122.79	240	51.16%	256.88	165.25	240	64.33%
2	253.70	126.89	240	52.87%	235.87	123.25	200	52.25%
3	249.00	101.24	240	42.18%	324.69	187.22	240	57.66%
4	221.17	107.33	240	44.72%	272.25	191.79	240	70.45%
5	275.20	68.48	240	28.53%	271.69	154.29	240	56.79%
6	244.07	113.37	240	47.24%	270.50	176.01	240	65.07%
7	220.28	121.07	240	50.44%	299.03	184.91	240	61.84%
8	228.33	107.48	240	44.78%	285.47	163.06	240	57.12%
9	72.52	47.19	160	29.49%	203.69	116.79	200	57.34%
Average	**224.4**	**101.76**	**231.11**	**43.49%**	**268.9**	**162.51**	**231.11**	**60.32%**

Remarks: Available working hours is calculated from working hours per week multiplied by the number of drivers.

Working hours are eight hours per day, six days per week. Therefore, the average available working hours are 231.11 hours, both prior to and after the implementation, as illustrated in Table 4.4. Driver utilization is calculated from the average available working hours divided by the average driving time. After GPS installation, drivers improved their utilization to 60.32 percent, increased from 43.49 percent, because

they realized that they were being monitored by their supervisor via the GPS tracking system.

Figure 4.1: Comparison of the Proportion of Driving Time in Traveling Time



According to Table 4.4, the average driving time, prior to and after GPS installation, is 101.76 and 162.51 hours per week respectively. It can be explained that the proportion of the average driving time to traveling time has increased from 45.35 percent to 60.43 percent as shown in Figure 4.1 as a result of increased driver utilization. Time wasting, such as over long resting time was eliminated by using GPS and that caused traveling time reduction. Finally the company may increase the number of trips in transporting goods after GPS implementation.

4.4.3 Analysis of Fuel Efficiency

Table 4.5: Comparison of Fuel Efficiency between Before and After GPS Installation

Average	Before GPS Installation	After GPS Installation	Fuel efficiency index
Driving distance (km)	32,032.50	31,131.92	-
Fuel consumption (liter)	3,413.56	2,776.07	-
Fuel efficiency (km/l)	9.38	11.21	19.51%

Remark: Average fuel price is 29.17 baht per liter.

Fuel efficiency is calculated from total distance divided by fuel consumption in a period of time. The outcome in Table 4.5 indicates that fuel efficiency increased from 9.38 kilometers per liter to 11.21 kilometers per liter. For comparison purposes, fuel efficiency index is the ratio of efficiency measured after the implementation period from the efficiency measured in a base or before the implementation period. Therefore, the result of fuel efficiency index is 11.21 divided by 9.38. It is equal to 1.1951. It can be explained that fuel efficiency had increased by 19.51 percent of the efficiency of the base period. Furthermore, increasing fuel efficiency would contribute to decreasing fuel consumption and fuel expense consequently. This improvement of fuel efficiency was because the company limited the speed of driving at 80 kilometers per hour. When the vehicle is being driving in excess of the speed limit, a GPS device is automatically alerted and records this information in GPS system. Drivers are notified and encouraged to slow down. Therefore, it is concluded that transportation efficiency was improved through increasing the fuel efficiency. Also, it helps the company save fuel expense and reduce the number of accidents.

Table 4.6: Historical Retail Price of High Speed Diesel Fuel in January to September 2011

Month	Average Fuel Price (THB/Liter)
January	29.99
February	29.99
March	29.96
April	29.99
May	29.99
June	29.99
July	29.99
August	28.70
September	28.05

Table 4.6 demonstrates the historical retail price of high speed diesel fuel from January to September in 2011. The company uses only this type of fuel in transportation. Although the retail price of fuel in this period slightly decreased, it was still high in the market. The company needs to seek cost effective ways to manage any

fuel expense which is unavoidable because it is a major expense in transportation for the company.

After analysis of the results, it was found that drivers' overtime working reduced, driver utilization increased and fuel efficiency also increased. These are synonymous terms used to measure the improvement of transportation efficiency, because transportation efficiency could be defined in many terms which closely related. From the above results, the implementation of a GPS tracking system could verify that transportation efficiency of CVC Company improved.

4.5 Summary

In conclusion, after reviewing and analyzing data from in-depth interviews, observation and document review, the collected data for prior to and after the implementation were compared in order to verify improvement in transportation efficiency. The implementation plan was conducted to solve the problem of low efficiency which could be explained by time and speed dimensions. In this study both dimensions comprise working overtime, driver utilization and fuel efficiency. These terms are used to measure transportation efficiency of the company. Finally this study concluded that the implementation of a GPS tracking system is able to improve transportation efficiency in CVC Company.

CHAPTER V

SUMMARY FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary of the Findings

This study aims to achieve the implementation plan of using a GPS tracking system in order to improve transportation efficiency of the CVC Company. The first objective is to understand the application of a GPS tracking system. After GPS system was utilized, comprehensive data has been provided to the company in order to monitor and control the drivers. Also, this technology helps the company to better manage its transportation department. As a result of GPS's application and ability to record driving speed, the company has setup a driving speed limit in order to save cost of fuel consumption. So it was found that CVC Company could increase kilometer distance in using one liter of fuel, from 9.38 kilometers per liter to 11.21 kilometers per liter. Furthermore, GPS tracking system enables the company to improve its management in the transportation department as it can provide comprehensive reports on a daily and monthly basis, such as idle time reports, excess speed reports, and alarm reports. When the driver has been driving over the speed limit, the system will send an alert signal to the driver as well.

The second objective in this study is concerned with developing a plan for GPS tracking system implementation for the transportation department of CVC Company. First, the implementation began by selecting the types of GPS tracking system, which consist of two types. The first type is a passive device and another is an active device. Both of them are able to provide time, speed and location information. However, the company decided to use the active device to solve the problem for the company due to its suitability. Searching for GPS equipment and installation could be done within two weeks. During this time some of involved staffs were trained in the use of GPS system by a consultant. The next step was to input relevant information as a database in GPS system. Then information regarding transportation of the company was

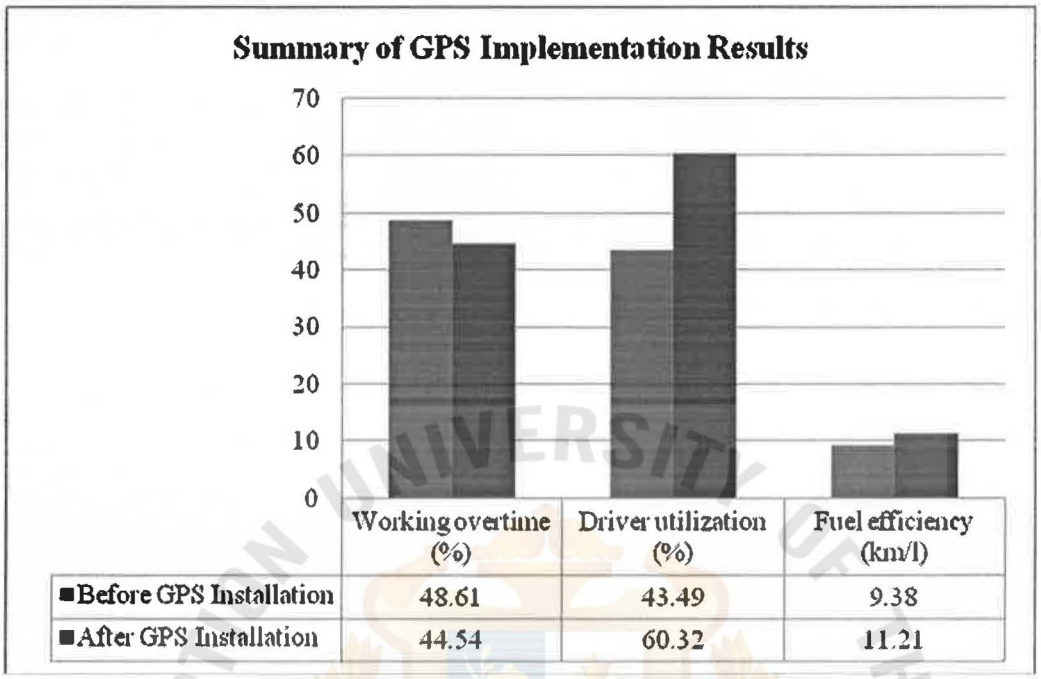
recorded to evaluate transportation efficiency. With this implementation, the company could replace written documentation by electronic data through using GPS system. Moreover, the transport manager had real time information about the location of the vehicle, which enabled him to develop goods transportation planning in order to assure increased efficiency and productivity of the drivers.

The last objective is to verify possible outcomes of the implementation of GPS tracking system. This study concentrates on the time in transporting goods, which was clarified in terms of working overtime, travel time, driver utilization and fuel efficiency. These four terms proved that the transportation efficiency of the company could be improved by implementation of GPS tracking system. As a result, drivers are going to be more careful and follow the rules, because they know they will be watched while they are working.

5.2 Conclusions

The results of this study present improvement in transportation efficiency by implementing a GPS tracking system. It also presents the GPS implementation plan for data collection and analysis, and the possible outcomes of before and after implementation of a GPS tracking system situation. GPS technology was selected as a tool in order to improve transportation efficiency in the transportation department of CVC Company. Under the proposal, GPS tracking system plays a major role in collecting data and providing real time data of the vehicles. The data minimized error and was more accurate when compared to the manual data collecting method which tends to record errors. Once the data was collected and analyzed, the importance of acknowledging the causes and effects, which identify the problem of low transportation efficiency, can lead to better understanding of the before and after implementation situations. There are several factors that impact on transportation efficiency. The results of this study provide verified outcomes which are able to improve transportation efficiency. Therefore the implementation of a GPS tracking system can eliminate the root cause of not having enough time in the transportation of goods.

Figure 4.2: Summary of GPS Implementation Results



	Working overtime (%)	Driver utilization (%)	Fuel efficiency (km/l)
■Before GPS Installation	48.61	43.49	9.38
■After GPS Installation	44.54	60.32	11.21

The graph in Figure 4.2 indicates the summary of GPS implementation results, compare to the situation before implementation, of each transportation efficiency term. It can be seen that after GPS implementation, all terms of transportation efficiency were improved, by reduction of working overtime, increase in driver utilization, and increase in fuel efficiency. In the time dimensions, after implementation working overtime was reduced 4.07 percent from before implementation. Driver utilization increased by 16.83 percent. It means that drivers can enhance the probability of completing their jobs in transporting goods within normal working hours. Therefore the company can save operational cost in order to generate more output. For the speed dimension, fuel efficiency increased by 19.51 percent because of speed limits. Drivers have controlled their driving speed and behavior during transportation of goods. They know that if they drive in excess of the speed limits, GPS system will alert their manager and record it in the GPS system automatically.

5.3 Theoretical Implications

Theoretical implications of this study are primarily for CVC Company, an industrial component manufacture, as well as other companies, researchers and students who look for knowledge of implementing a GPS tracking system. Other companies can use this study as a guideline to decide whether the company should adopt this tracking system to improve their transportation efficiency. As a result, this study can be applied in any business that has its own in-company transportation.

5.4 Managerial Implications

This research observed the GPS tracking system and also initiated a plan for implementation in order to enable the company to solve the problem of low transportation efficiency due to running out of time. The waste of time that occurred during goods transportation could be eliminated by using a GPS tracking system. The proposed suggestion will result in various benefits for the company, such as reduced working overtime, improved driver utilization, and increased fuel efficiency. The researcher believes that the GPS implementation can help the company reduce some vehicle expenses including fuel, distance, and maintenance as well as time. This study presents the types of GPS device and a comparison of the advantage and disadvantage of each type, how GPS system works, and the impact of implementation. So, this information is useful for CVC Company as well as other companies who intend to apply GPS tracking system in their organization. Moreover, the methodology in the implementation of GPS tracking system is provided by this study could enlighten the company as how the GPS tracking system works or what problems can be solved by this system, so that the company clearly understands the whole working process of the system.

5.5 Limitations and Recommendations for Future Research

This study aims to make an improvement in transportation efficiency at CVC Company. There are some limitations. Fisrt, the data may not reflect, or be generalized to other companies, in the manufacturing sector. Second, the study had limited financial data, such as driver's wages, so any data involve with the cost of the company cannot be shared and calculated. Third, the historical data for before the implementation is inadequate for analyzing some factors which could affect transportation efficiency. Additionally, this study encountered some difficulty in calculating and analyzing break-even figures for the installation the GPS device because some confidential data could not made available.

Future researchers still have other factors that can be used to evaluate the transportation efficiency, such as route, and the number of times over the speed limit, which could be found by future research. The data of this study was investigated in a short period of time, so future study should expand the time of data investigation. Reward and punishment systems may be explored for further analysis. Moreover, this study can be applied to the transportation department of other companies that have low efficiency.

BIBLIOGRAPHY

Ballou, R.H. (2004). *Business Logistics / Supply Chain Management*. Upper Saddle River, NJ : Prentice-Hall International. 5th edition.

Darnell, C., & Wilczoch, C. (2002). Real Time Positioning; Construction and implementation of a GPS-Communicator. Master's thesis in Control and Communication, LINKÖPING University.

Derekenaris, G., Garofalakis, J., Makris, C., Prentzas, J., Sioutas, S., Tsakalidis, A. (2001). Integrating GIS, GPS and GSM technologies for the effective management of ambulances. *Computers Environment and Urban Systems*, 25, 267-278.

Hafberg, G. (1995). Integration of geographic information systems and navigation systems for moving (dynamic) objects like vehicles and ships. Proceedings of ESRI User Conference, 272-274.

Hilletofth, P., Hilmola, O., & Claesson, F. (2010). In-transit distribution strategy: solution for European factory competitiveness?, *Industrial Management & Data Systems,* 111 (1), 20-40.

Holland, M. (2008). Research into Increasing Use of GPS Vehicle Tracking System, Retrieved July 20, 2011, from http://ezinearticles.com/?Research-Into-the-Increasing-Use-of-GPS-Vehicle-Tracking-Systems&id=1545167

Hugos, M., & Thomas, C. (2006). *Supply Chain Management in the Retail Industry.* NJ: John Wiley & Sons.

Imielinski, T., & Navas, J. (1999). GPS based geographic addressing, routing, and Resource discovery. *Communications of the ACM*, 42, 86-92.

Jung, H., Lee, K., & Chun, W. (2006). Integration of GIS, GPS, and optimization Technologies for the effective control of parcel delivery service. *Computers and Industrial Engineering*, 51, 154-162.

Kaplan, E.D., & Hegarty, C.J. (2006). *Understanding GPS, Principles and Application.* Artech House Inc., Norwood, United State.

Keenan, P. (1998). Spatial decision support systems for vehicle routing. *Decision Support Systems*, 22, 65-71.

Li, H., Kong, C.W., Pang, Y.C., Shi, W.Z., & Yu, L. (2003). Internet-based geographical Information systems for e-commerce application in construction and material Procurement. *Journal of Construction Engineering and Management*, ASCE, 129, 689-697.

Markovits-Somogyi, R., Bokor, Z., & Tibenszkyné Forika, K. (2010). Efficiency in Transport Logistics: an Academic and a Practical Viewpoint. *Acta Technica Jaurinensis Series Logistica*, 3 (3), 367-375.

Olano, J. (2007). *GPS Tracking Solution – Components of a GPS Tracking System Part 2*. Retrieved from http://ezinearticles.com/.

Sanchez-Rodrigues, V., Potter, A., & Naim, M.M. (2010). Evaluating the causes of Uncertainty in logistics operations, *International Journal of Logistics Management*, 21 (1), 45-64.

Spynews, (2011). *Understanding GPS Real Time Tracking*. Retrieved August, 12, 2011, from http://www.spyassociatesblog.com/2011/04/07/understanding-gps-real-time-tracking/

Sucharitkul, D. (2009). *Customer Satisfaction with Product Transportation: A Case of A Thai Diary Product Company*. Bangkok: Assumption University.

Symons, V.J. (1991). A review of information systems evaluation: content, context And process, *Journal of the Operational Research Society*, 1 (3), 205-12.

Thompson. (1999). *How GPS Works*. Retrieved August, 12, 2011, from http://www.gmat.unsw.edu.au/snap/gps/pdf/gps-article3.pdf

Weigel, D., & Cao, B. (1999). Applying GIS and OR techniques to solve Sears Technician-dispatching and home-delivery problems. *Interfaces*, 29, 112-130.

Yuan, H. (n.d.). Evaluation and Analysis of Urban Transportation Efficiency in China. Retrieved August, 20, 2011, from http://www.ville-en-mouvement.com/articles/ lu_huapu04. Pdf.

Zheng, Y., Liu, L., Wang, L., & Xie, X. (2008). Learning Transportation Mode from Raw GPS Dat for Geographic Applications on the Web. *International World Wide Web Conference Committee,* 247-256.

Zhong, H., & Zhou, B. (2011). Using Information Technology to Optimize Operations of Third-Party Logistics Provider. *International Journal of Management & Information Systems*, 15 (1), 115-122.

Zito, R., D'este, G., & Taylor, M. (1995) Global positioning systems in the time domain: How useful a tool for intelligent vehicle-highway systems? *Transportation Research*, 3 (4), 193-209.