Great Circle Distance Methode for Improving Operational Control System Based on GPS Tracking System

Benny Dwi Kifana
Informatics Department
Telkom Institute of Technology
Bandung, Indonesia
benjirosan@yahoo.com

Maman Abdurohman
Informatics Department
Telkom Institute of Technology
Bandung, Indonesia
m_abdurohman@yahoo.com

***Abstract*—Fleet monitoring conducted to determine the position of the movement of the fleet to a point of reference. There are three applications that are necessary for the implementation of the monitoring system. They are Global Positioning System (GPS), Geographic Information System (GIS) and Global System for Mobile Communications (GSM) technologies. The Great Circle Distance method with two equations, Vincenty and Haversine, is used to calculate the accurate positioning. The experiment results show that the use of the equation Vincenty have better performance in comparison to Haversine equation on overspeeding detection. Accuracy of monitoring is increasing as evidenced by increased frequency of position reporting.**

Keywords- GPS, GIS, GSM, Great Circle Distance, Haversine, Vincenty

I. INTRODUCTION

Vehicle operational, in a manufacturing company with the scope of the operational area is quite extensive, requiring a proper management system. One of the problems in controlling vehicle operation is the determination of position and vehicle speed. Position monitoring is needed to ensure that vehicles do not operate out of its area. While the speed of the vehicle needs to be monitored to ensure the operational safety of vehicles and drivers.

It is needed a vehicle position monitoring system that works in real time and accurate. In order to meet the needs it needed the supporting technologies that include the Global Positioning System (GPS), Geographic Information System (GIS) and Global System for Mobile Communications (GSM) technologies. GPS is used to detect the position of the fleet in the form of latitude and longitude coordinates, GIS serves as a provider of geospatial information and GSM as a medium of data communication between the fleet and control centers.

In calculating the distance traveled and speed of the fleet used Great Circle Distance method on the plan surface. In this method, there are two equations that used the Haversine and Vincenty equations. Vincenty geodesic equation takes into account the distance geometry approach ellipsoidal. While the distance geodesic equation Haversine uses an approach perfectly spherical geometry (sphere).

As reference distance to ensure the accuracy of the system, used the data stored in drive right records contained in each vehicle. System performance is measured based on accuracy of measurement results compare to the data recorded on drive right.

II. RELATED WORK

A. Geographic Information System (GIS)

Technology and methods used in the research of Global Positioning System (GPS) tracking system are Geographic Information System (GIS), Automatic Vehicle Location (AVL), and Great Circle Distance method.

Basically, the term geographic information system is a combination of three main elements, namely systems, information, and geography. The term "Geographic" is part of the spatial. It is also referred to geospatial [12]. So, Geographic Information System is defined as a system of information in processing, analyzing and producing geographically referenced data or geospatial data to support decision making in planning and land use management, natural resources, environment, transportation, municipal facilities, public services and others [13]. Since the mid-1970s, it has developed systems specifically designed to handle geographically referenced information in various ways and forms. These problems include: organizing data and information, giving information on specific locations and doing computation, giving an illustration of connectedness to each other, along with other spatial analyzes.

At first, geographic data is only presented on maps using symbols, lines and colors. These geometric elements described in the legend. In addition, various data can be overlaid on the same coordinate system. As a result of a map to be effective both as a media presentation tool as well as geographic data storage. A map always provides an image or symbol of the geographical element in the form of a fixed or static even necessary for a variety of different needs.

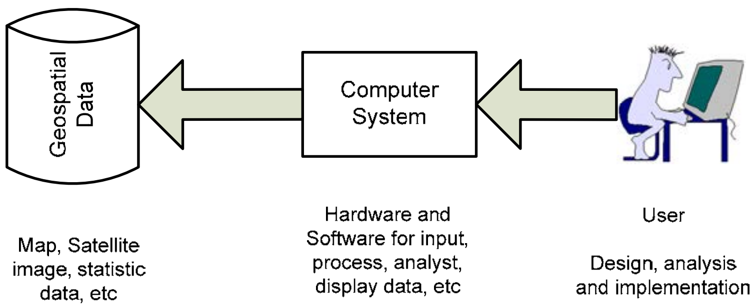


Figure 1. Main componenent of GIS

GIS is a complex system that is integrated with computer systems environment to another level of functional and network. The main components of GIS are computer systems, and geospatial data users [12]. The computer system consists of hardware (hardware) and software (software).

1. Hardware : GIS is available for a variety of hardware platforms ranging from PCs, desktops, workstations. The hardware used for the SIG as an input device is a mouse, keyboard, digitizer, scanner, digital camera, digital photogrammetric workstation. While the output device is a monitor, printer, plotter, film recorder, and others.
2. Software : This software consists of operating systems and applications. The operating system controls the entire operation of the program and connect the hardware to the application program.

Geospatial Data

GIS can collect and store the necessary data and information directly or indirectly by importing it from the GIS software as well as directly by digitize spatial data of the map and input the data attributes of tables and reports. Geospatial data may include maps, aerial photographs, satellite images, data and other statistics. Almost all areas can be facilitated by making use of geospatial data to support the implementation of regional autonomy. Spatial planning, land availability and the search for natural resources management and direction will be more rapid, precise and accurate if utilize this data and technology. Geospatial data is a unique data; it has geographical reference information, time, format data, relationships between objects as well as other information such as spatial resolution, scale and data sources.

GIS Framework

GIS can present the real world on a computer monitor as it can present a real world map on paper. However, the GIS has more powerful meaning and flexibility than the sheet of paper. Objects are represented on the map called the elements of a map or map features (eg a river, parks, gardens, roads, etc.). Since the map organizes the elements based on the locations, the map is very good in showing a relationship or a relationship that is owned by its elements.

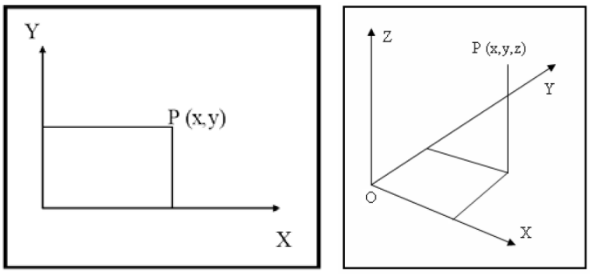
Map uses points, lines and polygons for representing the real-world objects. Map also uses graphic symbols and colors to assist in identifying the elements and descriptions. Map scale determines the size and shape representation of its elements. The more increase the scale of the map, the greater the size of its elements. GIS stores all descriptive information elements as attributes in the database. Then, the GIS forms and stores it in the tables (relational). After that, GIS connects these elements with the relevant tables. Thus, these attributes can be accessed through the locations map elements, and vice versa, the elements can also be accessed using map attributes. Connecting a set of GIS maps elements with their attributes in the role in units called layers. Collection of these layers will form the GIS database. Thus, designing a database is essential in the GIS. The database design will determine the effectiveness and efficiency of GIS input, management, and output processes[12].

B. Coordinate Systems

Coordinate system is a set of rules that determine how the coordinates of the points in question present. This rule generally defines the origin along with several axes of coordinates are used to measure distances and angles to produce the coordinates [12]. Coordinate system can be grouped according to: location starting point is placed (geocentric, topocentric, heliocentric, etc.), type of surface used as reference (plane, sphere, ellipsoid) and direction axes (horizontal and the equator).

1. Basic Coordinate System

These coordinate systems can present points in two-or three-dimensional space is often referred to as a Cartesian coordinate system.



(a) (b)

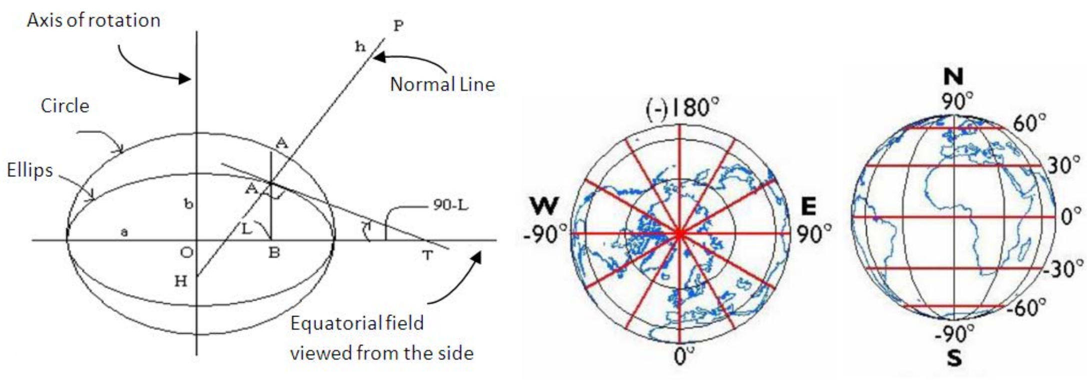
Figure 2. Cartesian coordinate system (a) Two-dimensional and (b) Three-dimensional

a. Two-dimensional coordinate system (plane)

Two-dimensional Cartesian coordinate system is a coordinate system consisting of two cross axes are perpendicular to each other, usually X and Y axis, as illustrated in Figure 2-a. P has the coordinates of the distance on the X axis is called the abscissa and has a distance on the Y axis is called ordinate.

b. Three-dimensional coordinate system

Three-dimensional Cartesian coordinate system, in principle, equal to two-dimensional Cartesian coordinate system, just adding one more axis of the Z axis, the three mutually perpendicular, as illustrated in Figure 2-b. Point O is the focal point of the three coordinate axes X, Y, and Z. While the point P defined by P (x, y, z). The use of three-dimensional Cartesian coordinate system is widely used in the measurements using GPS systems.



(a) (b) (c)

Figure 3. (a) Geodetic coordinates of latitude and altitude, (b) longitude and (c) latitude [8]

2. Global Coordinate System

Global coordinate system is commonly referred to global coordinates, the coordinates of the amount specified in degrees, minutes, and seconds on the corner of the axis system of geographic latitude and longitude.

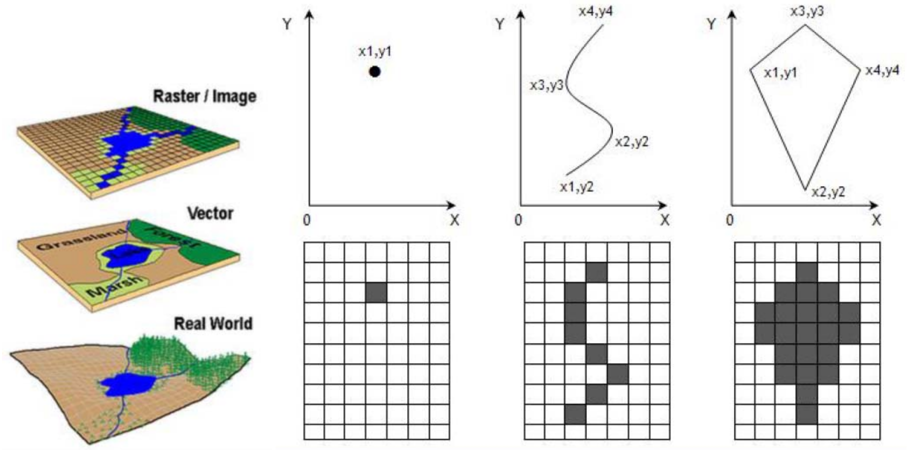
Longitude, latitude, and altitude

The most common coordinate system used is a system of latitude (φ), longitude (λ), and ketingggian (h). On this coordinate system, the prime meridian and the equator is the reference fields are used to define the coordinates of longitude (λ) and latitude (φ).

1. Longitude : Longitude is the line drawn from the center of the north pole to south pole to the center or vice versa. Longitude positions given by the measurement of angles ranging from 0 ° at the Prime Meridian to +180 ° eastward and -180 ° westward.
2. Latitude : Latitude is a line parallel or parallel to the equator, or equator. Latitude is usually denoted by the symbol of the Greek letter φ. Latitude is the calculation angle from 0 ° at the equator to the poles to +90 ° -90 ° north and south pole.
3. Altitude : Altitude expressed in altitude or elevation or depth perukuran place at the point, usually sea level.

C. Spatial Data Model

Traditional spatial data has been stored and shown in map form. Spatial data model that has been developed for storing geographic data digitally, namely raster and vector diagram below reflects the two main techniques providing spatial data encoding, namely raster and vector.



(a) (b)

Figure 4. (a) Spatial data model, raster and vector and (b) Vector and Raster comparisson [15]

Raster Data Model

Raster data is the data in the form of pixels arranged in rows and columns, storing spatial information in a grid or matrix. Each pixel has a value, and this value can present something. Spatial entities are stored in the raster layers of functionality that are related by elements of the map. Raster model provides spatial information of what is happening everywhere in the form of a generalized picture. With the raster model, geographic data characterized by values (numbers) of rectangular matrix element of an object. Conceptually, the raster data model is the simplest spatial data model [12].

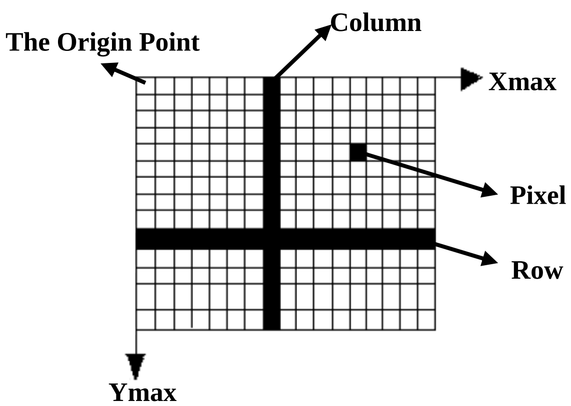


Figure 5. Raster data model structure [12]

Raster maps are the maps obtained from an area of photography, satellite images or Earth's surface images obtained from computer. One of the raster maps' variant is a map of the scanner or scan map. When scanning on a paper, a process of conversion into digital raster maps can be used as a layer on the map.

Vector Data Model

Vector data model display, place, and store spatial data using points, lines, or curves, and polygons and their attributes. Basic representation forms of this spatial data, in the vector data model system, defined by two-dimensional Cartesian coordinate system (x, y). In this data model, the lines defined as an ordered set of points connected. While the polygon is stored as a set list of points, with a note that the starting point and end point coordinates of the polygon have the same or a perfect closed polygon [12].

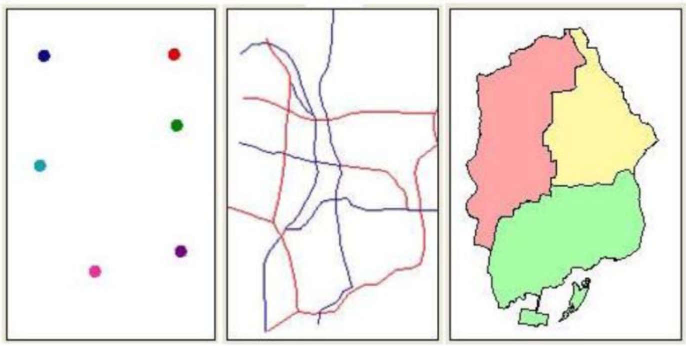


Figure 6. Vector data model consist of point, line and polygon [15]

Vector map is a map that was built from the merging of the various reference points and then through a special calculation of these points will be interconnected to form a line or a particular pattern.

Web-Based GIS

Web-based Geographic Information System is a GIS-based application that can run and apply to a web browser, either the application in a global computer network or in a Local Area Network (LAN) or in a PC computer that configured has networks setting in the web server. In general, the SIG was developed based on the principles of data input/entry, management, analysis and data representation. In the web environment such principles as drawn and implemented as in the table 1.

TABLE I. PRINCIPLES OF WEB-BASED GIS

GIS PRINCIPLE	WEB DEVELOPMENT
Input Data	Client
Data Manajement	DBMS with spatial component
Data Analysis	GIS library in server
Data Representation	Client/server

Web server is needed to be able to communicate with the different components in a web area. Because the standards of geodata is different and very specific, so system architecture follows the "client server" architecture.

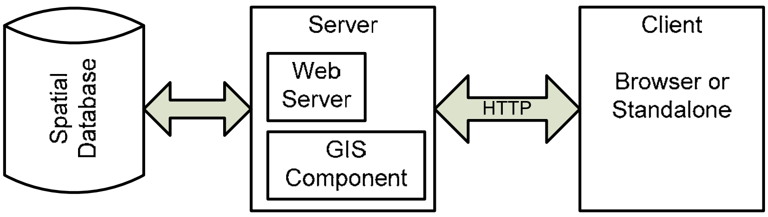


Figure 7. WEBGIS Architecture[16]

The web server is responsible for the process of client requests and send responses to the client. In web architecture, a web server also manages the communication with the server side GIS components. GIS server component is responsible for the connection to the spatial database such as translating queries into SQL and making representation to be passed to the server.

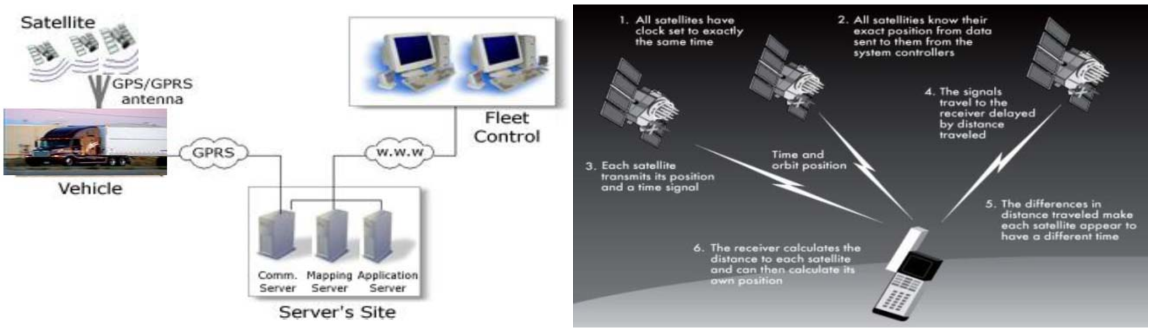
Automatic Vehicle Location

Automatic vehicle location is a vehicle tracking system that uses computer-based navigation to determine the actual position of the vehicle in real time and transmit the position to the control center. The process of determining the actual position of the vehicle and its delivery techniques are vary, depending on system of requirements and the transmition of technology chosen. Position information can be conveyed to the control center data in the form of raw data or processed before being transmitted.

D. Vehicle Positioning Determination Methods

In determining the actual position of the vehicle, AVL utilizes a navigation technology, one of which is GPS technology. GPS technology uses signals which transmitted by a network composed of 24 satellites that orbit the Earth and received by the GPS antenna mounted on the vehicle. A GPS receiver can calculate the position based on signals received from at least 3 satellites.

GPS stands for Global Positioning System is a system that determines global positioning and navigation using satellites. The system was first developed by the U.S. Defense Department is used for military purposes and civilian (surveying and mapping). GPS systems, whose real name is NAVSTAR GPS (Navigation Satellite Timing and Ranging Global Positioning System), has three segments, namely: the satellite, the controller and the receiver/user. GPS satellites orbiting the earth, with the fixed orbit and position, totaling 24 pieces in which 21 active and the rest is reserved.



(a) (b)

Figure 8. (a) AVL Architecture [18] and (b) GPS System [2]

Satellite receives and store the data transmitted by the controller stations, store and maintain precise time information (determined by the atomic clock in the satellite), and emits a continuous signal and information to the receiver of the user. The controller controls of earth satellites to examine the health of both satellites, and orbit determination and prediction of time, time synchronization between the satellite, and sends data to the satellite. Receiver receives and processes data from satellites to determine position (the position of the three-dimensional coordinates of the earth plus the height), direction, distance and time required by the user.

III. OPERATIONAL TRACKING SYSTEM USING GREAT CIRCLE DISTANCE

System architecture to be built is divided into three sub-systems namely vehicle navigation sub-system, data communication sub-system and control center sub-system. Vehicle navigation sub-systems to function as a determinant of position and time for the vehicle and then sent to control center sub-system via data communication sub-system. Design of vehicle navigation sub-systems visualized in Figure 9-a.

This sub-system comprises a GPS receiver as a means of positioning and timing, as well as data communications interface the serves to filter the data obtained from the GPS receiver and then transmitted to the control center. To run a vehicle communication interface, used computer or laptop.

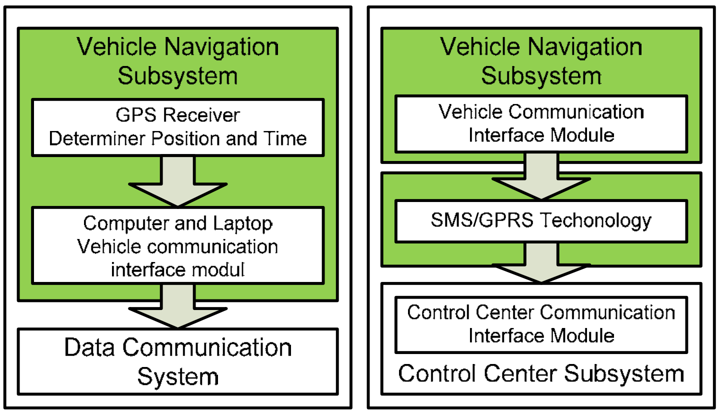


Figure 9. (a) Vehicle Navigation Sub-System Architecture and (b) Data Communications Sub-System Architecture

Data communication sub-system serves as a connection between the vehicle navigation sub-system and control center sub-system. Vehicle navigation data (position, date, and time) obtained on the vehicle navigation sub-system delivered through this sub-system to control center. This sub-system is associated with vehicle navigation sub-system and control center sub-system via the communication interface modules that exist in both sub-systems. Data communication sub-system design can be seen in Figure 3-2. This sub-system consists of vehicle/fleet is monitored fitted with a device called a GPS Tracking Device. This device will determine the position of the vehicle through which the signal transmitted from GPS satellites and automatically send position information to the system via GPRS (as the primary method) or SMS (as a back-up method). Data about the position of the vehicle sent by the device via SMS or GPRS communication media on the GSM network. In this research used the GSM provider Excelcomindo with GSM card used was XLcard. At the control center, data sent and received forwarded to a computer for processing.

Control center sub-system is the center of data processing, data visualization, and control of the vehicle. Position data transmitted by each vehicle is processed and visualized so that the manager has the convenience to manage the movement of the vehicle.

A. GPRS Data Packet Format

In the management system which will be built, the data transportation between the GPS tracker/receiver and the control center server network utilize GPRS and SMS as the mainstream media as the backup media.

TABLE II. GPRS DATA PACKET

Item	Spesification
@@	2 bytes. Marks the beginning of the packet to the server tracker. Defined in the ASCII code (HEX code: 0x40)
$$	2 bytes. Marks the beginning of the packet to the server tracker. Defined in the ASCII code (HEX code: 0x24)
L	2 bytes. The length of the packet data and is defined in hex code
ID	7 byte, ID number and the maximum number of 14 digits, the data byte is not used/no value is expressed by "f" or "0xff". Defined in hex code. Example, if the ID is 13612345678, then it can be defined as: 0x13, 0x61, 0x23, 0x45, 0x67, 0x8f, 0xff.
instruction	2 bytes. Defined in hex code. A list of commands will be described hereinafter.
data	Data in the form of a position based on the standard National Marine Electronics Association (NMEA). Minimum data length of 0 bytes and a maximum of 100 bytes
checksum	2 bytes. Indicates-CCITT CRC checksum value (default value is 0xffff) of all data (except the CRC value itself and the character that marks the end of the packet). Defined in hex code. Example: 24 24 00 11 13 61 23 45 67 8f ff 50 00 05 d8 0d 0a 0x05d8 = CRC-CCITT (24 24 00 11 13 61 23 45 67 8f ff 50 00)
\r\n	2 bytes. Marks the end of the packet data and is defined in hex code (0x0d, 0x0a)

The following will explain the format of data packets sent to the GPRS network.

From the server to the GPS Tracker:

@@<L (2 byte)><ID (7 byte)><perintah (2 byte)><parameter><*checksum* (2 byte)>\r\n

From the GPS Tracker to the server:

$$<L (2 byte)><ID (7 byte)><perintah (2 byte)><data><*checksum* (2 byte)>\r\n

TABLE III. COMMAND LIST

Login – 0x5000 Command:	$$<L><ID><0x5000><checksum><\r\n>
Notes	After doing the setup on the tracker, the tracker will send the login commands to the server every 30 seconds until the server to confirm the login.
Example	24 24 00 11 12 34 56 FF FF FF FF 50 00 8B 9B 0D 0A
Login Confirmation – 0x4000 Command:	@@<L><ID><0x4000><Flag><checksum>\r\n
Notes	The server sends the login request confirmation of the tracker.
Notes	Flag (1 byte) = 0x00, login failed and asked for login again. login= 0x01, the login is successful.
Contoh:	40 40 00 12 12 34 56 FF FF FF FF 40 00 01 A9 9B 0D 0A
Track on Demand – 0x4101 Command:	@@<L><ID><0x4101><checksum>\r\n
Notes	Ask for the current location of the tracker
Example	40 40 00 11 12 34 56 FF FF FF FF 41 01 67 D9 0D 0A
Respons	$$<L><ID><0x9955><data><checksum>\r\n
Example	24 24 00 60 12 34 56 FF FF FF FF 99 55 30 33 35 36 34 34 2E 30 30 30 2C 41 2C 32 32 33 32 2E 36 30 38 33 2C 4E 2C 31 31 34 30 34 2E 38 31 33 37 2C 45 2C 30 2E 30 30 2C 2C 30 31 30 38 30 39 2C 2C 2A 31 43 7C 31 31 2E 35 7C 31 39 34 7C 30 30 30 30 7C 30 30 30 30 2C 30 30 30 30 69 62 0D 0A
Track by Interval – 0x4102 Command:	@@<L><ID><0x4102><Interval(2 byte dalam kode hex)><checksum>\r\n in hex code

Notes	Set the time interval from the tracker position reports sent automatically.
Notes	Time interval is set in multiples of 10 seconds. Intervals up to = 65 535 * 10 seconds.
Example	The command above to set the time interval 10 (0x00 0x0A) * 10 = 100 seconds.
Respons	$$<L><ID><0x5100><Flag (1byte)> <Interval (2 bytes)><checksum>\r\n
Example	Flags = 0x00, the response failed .. = 0x01, successful response. After the lapse of time is received, the tracker will send a report to the server according to the position of the vehicle the desired time interval. $ $ <L> <ID> <0x9955> <data> <checksum> \ r \ n

For the purposes of positioning and timing data obtained from the GPS receiver, then use the format : Recommended Minimum Specific GPS / TRANSIT Data (GPRMC) which will be described in Table IV.

TABLE IV. GPRMC DATA FORMAT

<table>
<tr><th>Parameter</th><th>Description</th><th>Example</th></tr>
<tr><td>hhmmss.dd</td><td>Time Universal Time Coordinated(UTC) dd = h; mm = minutes, ss = seconds, dd = decimal part of seconds;</td><td>13:48:29.486</td></tr>
<tr><td>S</td><td>GPS status indicator, A = valid, V = Invalid</td><td>A=Valid</td></tr>
<tr><td>xxmm.dddd</td><td>Latitude xx = degrees; mm = minutes, dddd = decimal part of minutes;</td><td>22 deg. 32.6083 min.</td></tr>
<tr><td><N|S></td><td>Stating the north or south of N = North, S = South</td><td>N = Utara</td></tr>
<tr><td>yyymm.dddd</td><td>Lognitude yyy = degrees; mm = minutes, dddd = decimal part of minutes;</td><td>114 deg. 04.8137 min.</td></tr>
<tr><td><E|W></td><td>Stating the east or west E = East, W = West</td><td>E = Timur</td></tr>
<tr><td>h.h</td><td>Heading, in units of degrees</td><td>309.62 deg.</td></tr>
<tr><td>ddmmyy</td><td>Date dd = date; mm = month; yy = year</td><td>01,08,09</td></tr>
</table>

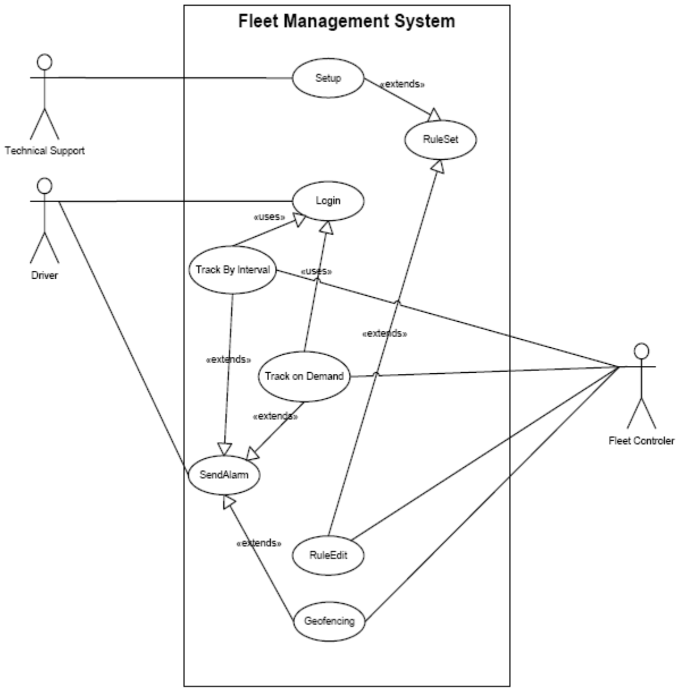
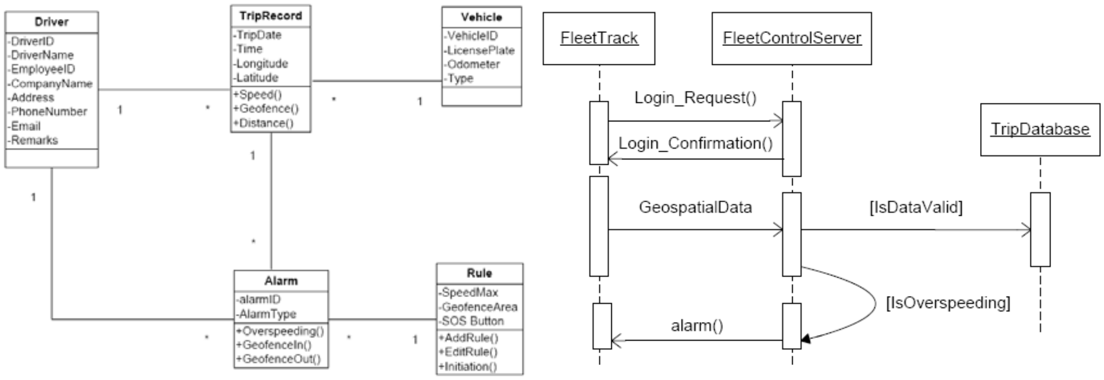


Figure 10. Use Case Diagram

B. System Design

Figure 10 shows that there are three actors in the development of a fleet management system, which are technical support, fleet tracker (driver), and the fleet controller are located at the control center. Technical support conducts the initial setup like the tracker determines the server address and port for data communication, such as the rule to determine the maximum speed limits, interval data delivery fleet position and set the SOS buttons.



(a) (b)

Figure 11. (a) Class Diagram and (b) Sequence Diagram

After the tracker in the setup, when the fleet is turned on (ignition on) then the tracker will automatically send a login request to the server address and port that has been defined by technical support. After getting confirmation from the server, then the tracker periodically transmit position data according to a predetermined interval. In terms of fleet controller, it is able to make changes to the initial setting on the tracker, monitor changes in the position of the vehicle through a digital map, or send an alarm.

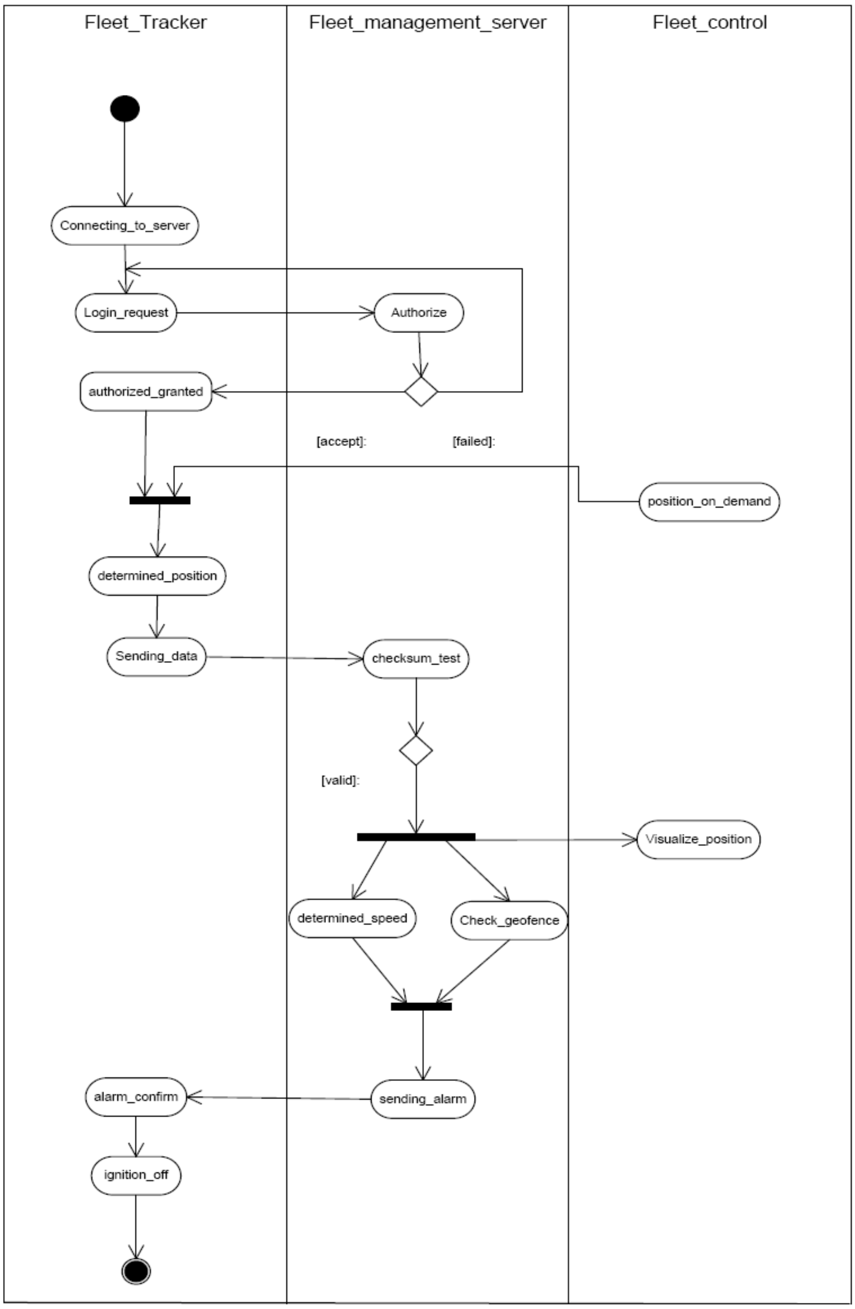


Figure 12. Activity Diagram

Figure 11-a, describes many tables that will be contained in the database, including the driver, a trip record, vehicle/fleet and rules and setting of the area geofence. Figure 11-b, the sequence diagram explaining the outline of the process of connection initiation between the track and fleet control center through the login process and login prompt. Once the login is valid, fleet track sends position and time data periodically according to a preset frequency. If the control center detects the speed of the fleet that exceed the maximum limit, then the alarm will be sent as a warning sign.

C. Equations Great Circle Distance

Haversine Equation

R = radius of the earth (average = 6,371 km)

$$\Delta lat = lat_2 - lat_2 \quad (1)$$
$$\Delta long = long_2 - long_2 \quad (2)$$

From equation 1. and 2. obtained the difference between longitude and latitude of the starting point and destination point

$a = sin^2\left(\frac{\Delta lat}{2}\right) + \cos(lat_1) . \cos(lat_2) . sin^2(\frac{\Delta long}{2})$ (3)
$c = 2. atan2\left(\sqrt{a}. \sqrt{(1-a)}\right)$ (4)
$d = R. c$ (5)

d is the distance of two points on the earth's surface

$\theta = atan2(\sin(\Delta long). \cos(lat_2) . \cos(lat_1). sin(lat_2) - sin(lat_1). cos(lat_2). \cos(\Delta long))$ (6)

equation 6 would result in the value of the angle between the starting point and destination point

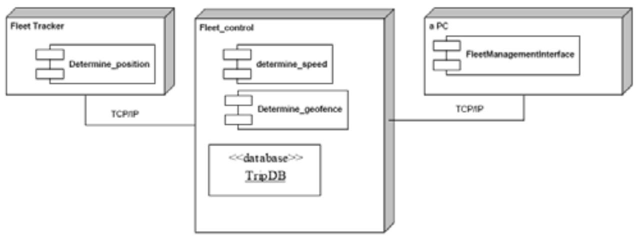


Figure 13. Deployment Diagram

Vincenty Equation

a, b = radius of the earth at the equator and pole (based on an ellipsoidal shape of the earth)
f=(a-b)/a
φ_1, φ_2 = latitude values starting point and end point
L = the differency of longitude values
$U_1 = \text{atan}\ ((1-f). tan\varphi_1)$
$U_2 = \text{atan}\ ((1-f). tan\varphi_2)$
$\lambda = L$

do iteration until the value of lambda is very small and negligible

$sin\sigma = \sqrt{((cosU_2. sin\lambda)^2 + (cosU_1. sinU_2 - sinU_1. cosU_2. cos\lambda)^2)}$ (7)
$cos\sigma = sinU_1. sinU_2 + cosU_1. cosU_2. cos\lambda$ (8)
$\sigma = atan2(sin\sigma, cos\sigma)$ (9)
$sin\alpha = \frac{cosU_1.cosU_2.sin\ \lambda}{sin\sigma}$ (10)
$cos2\sigma_m = cos\sigma - 2. sinU_1. sinU_2 / cos^2\alpha$ (11)
$C = f/16. cos^2\alpha. [4 + f. (4 - 3. cos^2\alpha)]$ (12)
$\lambda' = L + (1-C)f. sin\alpha\{\sigma + C. sin\sigma[cos2\sigma_m + C. cos\sigma(-1 + 2. cos^2 2\sigma_m)]\}$ (13)
$U^2 = cos^2\alpha. (a^2 - b^2)/b^2$ (14)
$A = 1 + U^2/16384. \{4096 + u^2[-768 + u^2(320 - 175. u^2)]\}$ (15)
$B = u^2/1024. \{256 + u^2[-128 + u^2. (74 - 47u^2)]\}$ (16)
$\Delta\sigma = B. sin\sigma. \{cos2\sigma_m + B/4[cos\sigma. (-1 + 2. cos^2 2\sigma_m) - \frac{B}{6}. cos2\sigma_m(-3 + 4sin^2\sigma)(-3 + 4. cos^2 2\rho_m)]\}$ (17)
$s = b. A. (\sigma - \Delta\sigma)$ (18)
$\alpha_1 = atan2(cosU_2. sin\lambda, cosU_1. sinU_2 - sinU_1. cosU_2. cos\lambda$ (19)
$\alpha_2 = atan2(cosU_1. sin\lambda, -sinU_1. cosU_2 + cosU_1. sinU_2. cos\lambda$ (20)

Information :

S is the distance of two point coordinates based on the Vincenty equation, while α_1 and α_2 is the beginning and end angle.

IV. EXPERIMENT AND ANALYSIS

A. Hardware and Software

The hardware used in this research are as follows: 1. Laptops with specifications: a. Intel Core ™ 2 Duo 2.0 GHz b. 1024 MB DDR2 Memory c. VGA Mobile Intel ® 128MB Internal d. 160 GB hard drive e. Serial port, 2. Mobile phone Nokia E71, 3. GSM SIM card XL, 4. GPS Tracking Meitrack VT300, 5. Right Drive USB to serial converter, 6. Handled GPS tracker.

The software used in the implementation are: 1. MapServer 4.4, 2. MapInfo Professional 8.0 3. MapBasic 4. Google Earth Desktop 5. Sun Java Runtime Environment 5 6. Drive Right Fleet Management Software 3.4

B. Testing Scenario

In the development of GPS-based fleet management tracking system, there are many research factors that can be studied:

1. Geospatial data received by GPS receiver
2. Mileage data, average speed and maximum speed obtained from DriveRight. This datum will be used as a benchmark to measure the accuracy based on data obtained from GPS.
3. Comparison of the amount of data based on valid and invalid checksum value received by the control center. These parameters will affect the accuracy of the speed and mileage calculation due to a broken or loss of data.
4. Interval delivery of geospatial data from tracker reports to the control center. For this parameter, the authors tried three values of the interval, which is 10 seconds, 30 seconds and 60 seconds.
5. For the purposes of the maximum velocity parameter, the authors use the maximum speed is 40 Km/Hr.

Observation system which lasted for four days, starting on May 2 to May 5, 2011.

Figure 14. Vector Area Map

C. Results Analysis

1. Accuracy Analysis of Position

To determine the level of accuracy of data obtained through GPS positioning, the authors tested the system by measuring the position of the fleet at the idle time. The study was conducted in the parking area of the mosque Al-Fattah with reporting interval for 10 seconds.

TABLE V. FLEET POSITION DATA AT IDLE TIME

Date	Time	Latitude(DMS)	Longitude(DMS)
05/05/2011	11:07:37	0°44′58.53″N	101°27′08.86″E
05/05/2011	11:07:47	0°44′58.44″N	101°27′08.86″E
05/05/2011	11:07:57	0°44′58.44″N	101°27′08.86″E
05/05/2011	11:08:07	0°44′58.44″N	101°27′08.88″E
05/05/2011	11:08:17	0°44′58.44″N	101°27′08.88″E
05/05/2011	11:08:27	0°44′58.53″N	101°27′08.81″E
05/05/2011	11:08:37	0°44′58.53″N	101°27′08.81″E
05/05/2011	11:08:47	0°44′58.53″N	101°27′08.86″E
05/05/2011	11:08:57	0°44′58.46″N	101°27′08.80″E
05/05/2011	11:09:07	0°44′58.46″N	101°27′08.80″E

05/05/2011	11:09:17	0°44′58.46″N	101°27′08.80″E
05/05/2011	11:09:27	0°44′58.44″N	101°27′08.81″E
05/05/2011	11:09:37	0°44′58.46″N	101°27′08.80″E
05/05/2011	11:09:47	0°44′58.46″N	101°27′08.80″E
05/05/2011	11:09:57	0°44′58.46″N	101°27′08.80″E
05/05/2011	11:10:07	0°44′58.46″N	101°27′08.80″E
05/05/2011	11:10:17	0°44′58.46″N	101°27′08.80″E
05/05/2011	11:10:27	0°44′58.46″N	101°27′08.83″E

Based on data received from 18 position, obtaining the coordinates modus of the fleet that is 0 ° 44'58 .46 "north latitude and 101 ° 27'08 .80" east longitude. Deviation value is 0°44'58.53" north latitude and 101 ° 27'08.86" east longitude. So that the accuracy of the fleet at idle time in this system is 2.8 meters. This value is obtained from the calculation of the distance between the modus and the outer junction.

2. Accuracy Analysis of Mileage

To determine the level mileage accuracy obtained through the calculation of the great circle distance equation, the author compared between the total mileage obtained from each of the test data and the total mileage earned through DriveRight

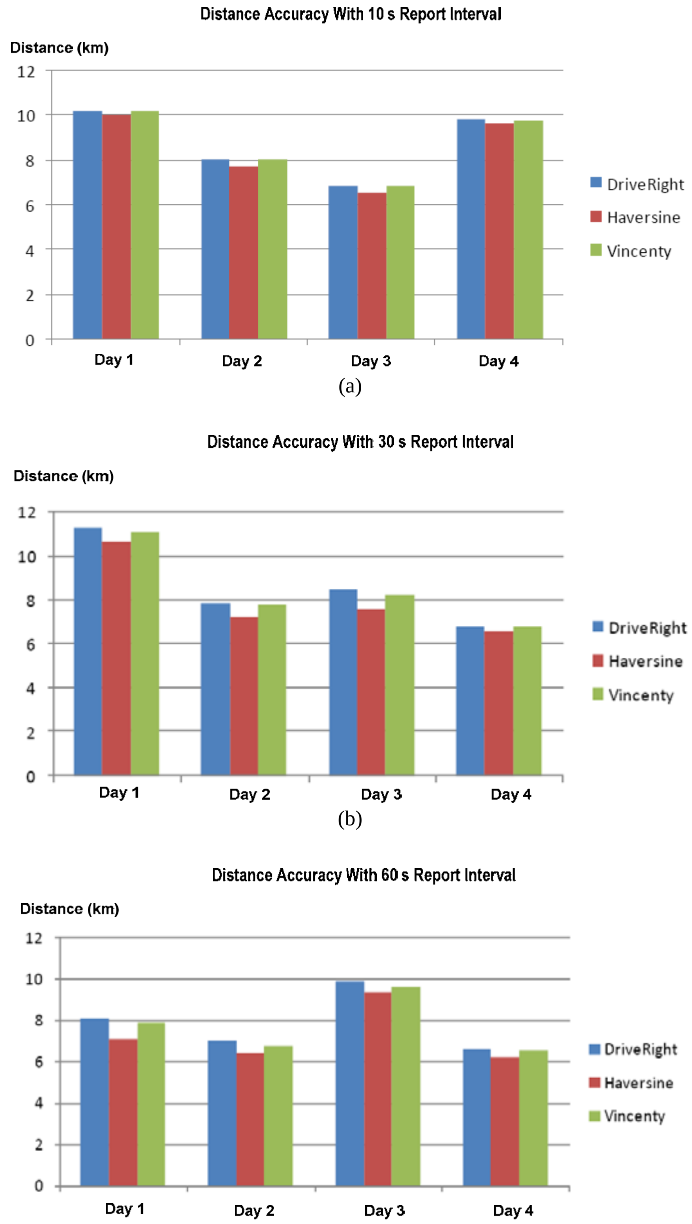
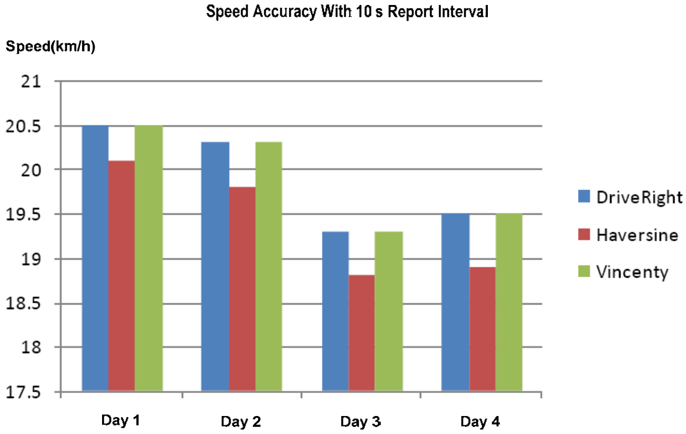
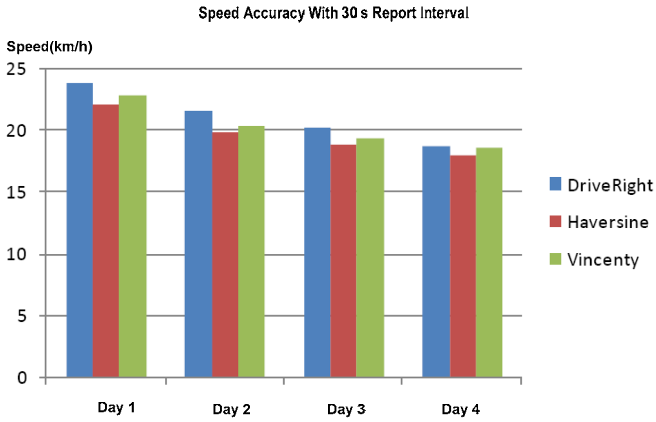


Figure 15. Fleet Mileage chart for (a) 10 seconds, (b) 30 seconds and (c) 60 Seconds Interval report

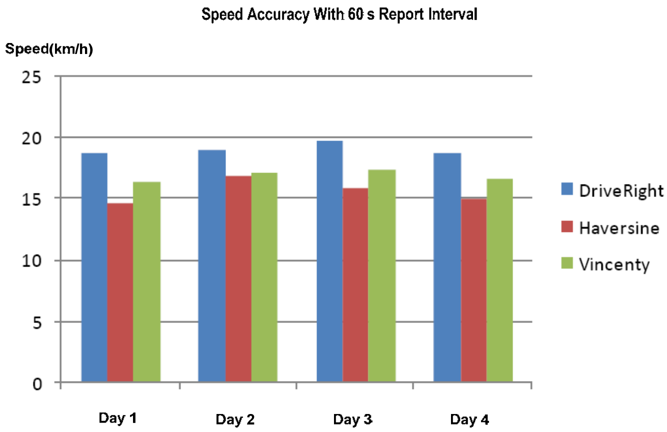
In Figure 15-a, shown with 10 seconds interval reports, mileage accuracy is obtained through equation Vincenty close distance measured at Driveright. Based on a 4-day study, the average difference between the calculated values and data DriveRight Vincenty equation is 10 to 12 meters. While the equation Haversine generate different values an average of 343 meters compared with data obtained from DriveRight. Can be seen that the interval is too large can reduce the accuracy in calculating the fleet mileage traveled. So that the intervals of 10 seconds can be the exact value as the GPS data reporting interval.



(a)



(b)



(c)

Figure 16. Graphic comparison of average speeds in the interval (a) 10 seconds, (b) 30 seconds and (c) 60 seconds

Based on three test scenarios that have been made, it can be seen that the testing of the performance of the Great Circle Distance (Vincenty and Haversine equations) in this case is strongly influenced by data transmission interval. But overall this method is able to calculate the distance armada to the level of correction that is fair or be ignored. The difference in accuracy between Vincenty and Haversine equations obtained and caused characteristic differences between the two, which Haversine equation calculates the distance between two points on the earth's surface with the assumption that the earth geometry whole round (spherical). This is shown by the use of the magnitude of the radius of the Earth at 6.371 km. While the Vincenty equation takes into account differences in the radius of Earth's equator and the radius of the earth at the poles according to the original geometry of the earth is egg shaped (ellipsoidal).

In addition to the influence of the accuracy of the above equation, the correction factor (error) caused by the presence of invalid data based on the received checksum value that can be caused by the use GPRS network quality is poor. In addition, poor signal quality in the study area resulted in a GPS receiver will lose track of the satellite that has been previously localized, so that often requires re-initialization process between the receiver and the GPS satellites. The time required to initialize the connection between the receiver and the satellite has resulted in some of the data is not sent in the interval of sending data that has been set.

3. Accuracy Analysis of Speed

For purposes of fleet speed of analysis, the authors calculate the speed based on the equation $v = \frac{s}{t}$ where the distance (s) is calculated based on the position of two points using the equation Haversine and Vincenty. For time (t) is used the interval between the two points.

Figure 16-a shows that the Vincenty equation able to calculate the speed of the fleet better than Haversine equation. Accuracy in calculating the speed of the fleet is affected by the accuracy in the calculation of the distance between two points on the earth's surface. In line with the calculation of the average vehicle speed, the Vincenty equation is more accurate on overspeeding detection than Haversine equation.

Figure 16-b, shows that the degradation or reduction of accuracy in calculating the average speed of the fleet at an interval of 30 seconds. This indicates that the interval of 30 seconds is not possible for the system to detect changes in the fleet with the proper acceleration.

Figure 16-c, shows that the degradation or decrease in accuracy is more significant in calculating the average speed of the fleet at intervals of 60 seconds. And the third is based on the graph above it can be concluded that the monitoring system at intervals of 10 seconds is reporting an ideal system in determining the speed of the fleet.

4. Analysis of Geofence Alarm

To test the ability of the system in detecting the presence of the fleet relative to the specific geofence area, there are test scenarios which defined a circular geofence gas station in the area with the coordinates of the center of the circle is 0 ° 44'43 .31 "north latitude and 101 ° 27'50 .36" east longitude. Geofence defined radius is 180 meters. 4-10 looks at the illustration in which the alarm goes off due to the fleet entered the gas station area. The system detects the presence of the fleet by comparing the relative distance between the fleets of the central point geofence. In the above example the distance between the fleet and geofence central point is 157 meters and smaller than the 180-meter radius geofence. So that the fleet was expressed over the area and the alarm transmitted geofence. These data geofence area setting and alarm data is sent via GPRS to a control system and sms to a number of authors.

Parameter setting request data geofence 40 40 00 42 82 26 FF FF FF FF FF 42 07 31 30 31 32 37 2E 35 30 33 36 2C 45 2C 30 30 34 34 2E 34 33 33 31 2C 31 38 30 2C 4E E5 90 0D 0A

Geofence alarm data Data alarm geofence 24 24 00 68 22 6F FF FF FF FF FF 99 99 13 31 30 32 39 31 36 2E 30 30 30 2C 41 2C 30 30 34 34 2E 34 37 37 30 2C 4E 2C 31 30 31 32 37 2E 34 37 33 32 2C 45 2C 32 37 2E 36 39 2C 2C 30 35 30 35 31 31 2C

V. CONCLISION

Great circle distance method can be used to improve the operational control of the vehicle at a position of tracking system. The use of equation Vincenty has better performance compare to Haversine equiation in detecting overspeeding. Vincenty equation can accommodate earth's surface condition that has ellipsoidal shaped. The accuracy of monitoring increases in accordance with the increased frequency of position reporting.

FUTURE WORKS

In improving the accuracy of the position, subsequent studies can use GPS Deferential technology. It is needed to conduct a research on the effect of delay in the ionosphere and troposphere layer of the signal quality and accuracy of positioning data obtained. System should be developed for the cases where the area of research that has very uneven topography contours.

Acknowledgment

Maman Abdurohman thanks to the Telkom Institut of Technology and Informatics Faculty for their financial support and research resources so that this research could be completed

REFERENCES

[1] Abidin, 2000, "Penentuan Posisi Dengan GPS Dan Aplikasinya", Jakarta : PT. Pradnya Paramita

[2] Aerospace, 2005, How GPS Works, www.aero.org/education/primers/gps/howgpsworks.html, diakses pada tanggal 10 April 2011

[3] Anonim, 2006, Peta Kecamatan Pekanbaru kota, http://www.skyscrapercity.com/showthread.php?p=11387807 diakses pada tanggal 25 April 2011

[4] Charter, D., 2004, "MapInfo Professional", Bandung: Informatika

[5] Harmon, J.E. and Anderson , S.J., 2003, "Design and Implementation of Geographic Information Systems", New Jersey

[6] Humerfelt, S.,1999, Earth According to WGS1984, http://home.online.no/~sigurdhu/Grid_1deg.htm, diakses pada tanggal 17 April 2011

[7] ILWIS, 2008, Objects Appendices, www.spatial-analyst.net/ILWIS/htm/ilwis/appendices_ilwis_objects.htm diakses pada tanggal 10 April 2011

[8] John Dewey High School, 2011, Regents Earth Science Page, http://earthphysicsteaching.homestead.com/JDHS_Earth_Science_Page.html, diakses pada tanggal 7 April 2011

[9] Kapllan, 1996, "Understanding GPS Principles and Application", London: Artech House

[10] Lillesand dan Kiefer, 1998, "Penginderaan Jauh dan Interpretasi Citra Penginderaan Jauh", Yogyakarta : Gadjah mada University Press

[11] Parkinson, B.W., 1996, "Global Positioning System: Theory and Applications", Washington, D.C. : American Institute of Aeronautics and Astronautics

[12] Prahasta, E., 2001, "Konsep-Konsep Dasar Sistem Informasi Geografis", Bandung : Informatika

[13] Prayitno, T.A., 2006, "Pengantar Geografis Information System", Yogyakarta : ANDI

[14] Rigaux, P., 2002, "Spatial Databases With Application to GIS", San Fransisco : Morgan Kaufman

[15] RSandGIS, 2008, Introduction to GIS, http://www.rsandgis.com/index.php? kategori=1&otherposting=1 &postingid=30&postingcode=1, downloaded on April, 10th 2011

[16] Santitamnont, P., A Comparative Assessment of Internet GIS Server Systems, 2009, www.geospatialworld.net/index.php? option=com_content&view=article&id=14012, downloaded on April, 14th 2011

[17] Sosrodarsono, S. dan Takasaki, M., 1983, "Pengukuran Topografi dan Teknik Pemetaan", Jakarta : PT. Pradnya Paramita

[18] Transway, AVL system, www.transway.co.il/avl.htm, diakses pada tanggal 10 April 2011

AUTHORS PROFILE

Maman Abdurohman is a lecturer at Telkom Institute of Technology. He is working at faculty of Informatics of Telecom Institute of Techonolgy – Bandung. His primary areas of interest include embedded system design and microcontroller. Maman has an master and doctoral degree from Bandung Institute of Technology. Contact him at mma@ittelkom.ac.id/m_abdurohman@yahoo.com

Benny Dwi Kifana is a programmer of information system. His primary programming areas of interest include Geografical Informationa System (GIS) and Executive Management System. Contact him at benjirosan@yahoo.com