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TRACK ACCESS SYSTEM FOR HAZARDOUS CHEMICALS BASED ON MULTIPLE NETWORKS

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ABSTRACT

Catastrophic accidents caused by the leak of hazardous chemicals in the storage and transportation process occurred frequently, in order to seek for a continuous, all-location, real-time solution for tracking, positioning the vehicles transporting dangerous hazardous materials，this paper design a track access system, which is the integration of Global Positioning Systems(GPS), Google Earth geographic information systems, the GSM information systems and computer data processing technology. The locus access system obtains the raw GPS data from truck/ship-borne positioning terminal, and then transfer to the PC through USB, at last, the PC extracts and analyzes these data and execute coordinate transformation, and map these locations which point to the GPS data on the screen, forming a locus. The accurate knowledge integrated in the system of supervision of hazardous materials transportation ensures the establishment of early warning of hazardous chemicals leakage and accurate monitoring of storage and transportation. The integrated positioning monitoring system is found flexible, reliable and accurate for recording trace of the target under practical site conditions, is a mainstream of modern hazardous goods logistics.

Keywords: *GPS, Google Earth, GSM / GPRS Information Systems, Hazardous Chemicals, Track, Leakage*

1. INTRODUCTION

Along with the rapid industrialization process, the production and transportation of various hazardous substances has also aggrandized dramatically in China. Several surveys have indicated augment in the frequency of malignant accidents in the transportation of hazardous materials, which has caused huge losses of economy and lives and poor social impact [1]. For example, in the evening of March 29, 2005, a tank car carrying 35 tons of liquid chlorine collided with a lorry on the Beijing-Shanghai Expressway, which has give rise to the leakage of liquid chlorine seriously. The economic and environmental consequences: the villagers and driver suffer, 29 deaths,456 villagers of three towns on the side of the road in Huai’an poisoned hospitalization，1867 outpatients who have to stay hospital, more than 10,500 villagers had to be evacuated. Certainly, the Beijing-Shanghai Expressway sections cannot do anything but shut

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down for 20 hours, and economic losses amounted to $17.3994 million [2]; The main reasons that result in inappropriate reactions to events include [1-3]: Late and useless information of provided to aid workers; Lack of real-time knowledge of the location of accident; Exposure of first rescue teams and civilian populations to unknown hazards.

In alert and emergency situations, we designed a real-time track access system to reduce the occurrence of accidents, and improve precautions, intervention procedures and schemes [4]. It realized overall positioning and tracking the truck or ship carrying dangerous goods by GPS, display real-time trajectory by Google Earth, and real-time communication with the main control center through GSM network [5]. Accurate monitoring and positioning facilitate arranging for effective rescue measures timely when a sudden accident, and has broad application prospects and application value.

2. VECHILE POSITIONING MONITORING TERMINALSYSTEM ARCHITECTURE

Considering all kinds of problems in the transportation of hazardous substances, it is perfect to put forward such a tracking and positioning system based on GPS, Google Earth, GSM (3G) so as to intervention teams to react immediately with maximum safety in the event of a dangerous situation. The system consists of two parts: Truck/ship-borne positioning terminal, tracking and monitoring terminal as shown in Fig. 1

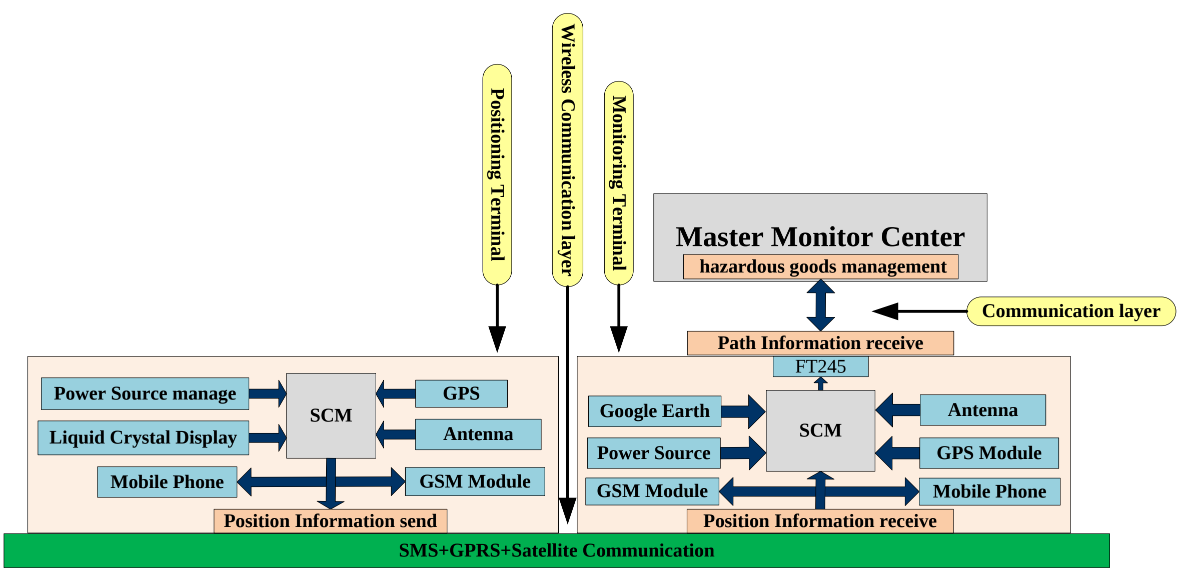

Figure.1. Overall System Architecture Diagram

Truck/ship-borne positioning terminal is constituted by GPS module, GSM module, C8051F040 master control unit and so on, which is shown in Fig. 2. It is a comprehensive integrated system based on "3G" which completes collection and processing of various spatiotemporal information and sends them through GSM module in the form of Short Messaging Service (SMS) or General Packet Radio Service (GPRS).The truck/ship-borne positioning terminal is mainly

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composed of GPS module, GSM module, FT245 module, Google Earth, C8051F040 main control unit, etc [6]. Positioning Monitoring terminal performs the receiver of positioning data from truck/ship-borne positioning terminal and transforms to frames, after the operation, the server transmits positioning data to PC in the way of parallel data through the FT245 module，so as to achieve the purpose of accelerating speed of upload. In addition, a different GPS that fixed on the Positioning Monitoring terminal transfers itself real-time spatiotemporal information to PC in the same way. It is crucial for PC to load various positioning information and make a final judgment, and display real-time trajectory of truck/ship-borne positioning terminal and Positioning Monitoring terminal. It is without doubt that PC is the highest level of management system of this system.

2.1 Truck/Ship-Borne Positioning Terminal

Truck/ship-borne positioning terminal is composed of the GPS receiver, GSM design, and SCM C8051F040, which is shown in Fig.2.

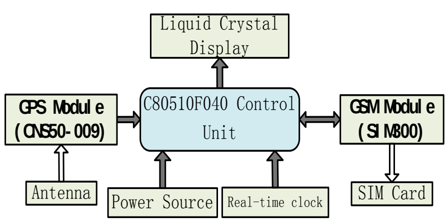

Figure.2. Truck/Ship-Borne Positioning Terminal Structure Diagram

Our research has drawn on the GPS, CNS50-009, which is yielded by a company named Eastern Star and developed for military application, with the following reasons: a unexceptionable operating temperature range of -40 ℃ to +8

strong anti-jamming capability, two kinds of data format: Binary and NMEA [7], and the most important thing is the CNS50-009 is not be limited by the top speed, etc. According to above, it is very suitable for our truck/ship-borne positioning terminal which operates in harsh environment generally. Then, the SIMCOM's SIM300 be used as our GSM / GPRS module that offers a wide range of operating temperature and operating frequencies from EGSM 900MHZ to DCS 1800MHZ and integrates the complete RF circuit, TCP / IP protocol and GSM baseband processor, the device is a low power static and high cost performance design[8]. In addition, we send correlative short message in our GSM module through the SIM card.

In this article, truck/ship-borne positioning terminal takes satellite positioning as the main positioning means, supplemented with inertial navigation, terrain-aided navigation and other technologies to obtain real-time vehicle location information, which is then integrated into the mobile geographic information system technology that can provide vehicle location, path planning, information query and other functions whenever and wherever possible. After receiving positioning information from GPS, the SCM parses the received NMEA string information to extract positioning information, such as latitude, longitude and elevation and so on, and then sends them to GSM module, which is the main device of wireless communication network [9].

2.2 The Tracking And Monitoring Terminal

The main framework of the tracking and monitoring terminal is constituted by the GPS server, the SCM design, the GSM module [10], the design of Google Earth and PC server, as shown in Fig. 3.

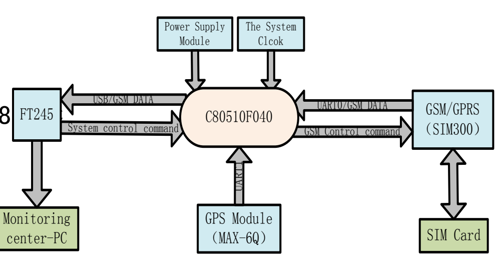

Figure.3.The Tracking And Monitoring Terminal Structure Diagram

The GPS server is responsible for receiving and

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forwarding data, which receives GPS positioning information and other information of the tracking and monitoring terminal, and then sends it to the SCM. Meanwhile, the GSM module also receives GPS positioning information and other relevant information from truck/ship-borne positioning terminal to the SCM. After this operation, the FT245 module implements information transmission from the tracking and monitoring terminal to PC, which sends the truck /ship loading positioning terminal and track and monitor terminal's location and alarm information to the monitor service center, and receives instructions sent from the monitor service center. That is to say, the SCM completes GPS signal receiving, processing and sending. Track display is implemented by programming with VC and calling Google Earth in the PC, which mainly includes map operations, the details of the location where a moving target stands in real time, zoom in, zoom out, roam, etc.

3. THE WHOL SOFTWARE FRAME WORK OF VECHILE POSITIONING MONITORINF SYSTEM

In the track access system, track data of a vehicle carrying hazardous chemicals has massive volumes of data about spatial location, resulting in a huge amount of data storage and inefficient data manipulation. In order to improve the storage efficiency and effective management of vehicle track data, we need to establish an effective data management approach to reduce data redundancy and increase the efficiency of information query. So it's a better solution to use C++ as the develop language and Visual C++ as the develop environment of the system thanks to its high efficiency and perfect function, which supports the COM technology as well as API invoking. The program of the whole system is divided into two sub-systems: data management and vehicle track display.

Vehicle track display and analysis is vital to monitoring the motion of a object carrying hazardous chemicals, in our research, we turned to Microsoft Visual Studio2005(VS 2005)of Microsoft, it has been widely used thanks to (1) supporting Data organization described by XLM and (2) providing XLM designer which facilitate creating XML document, importantly, (3) KML file applying the exchange for geographic data in Google Earth map browser is also XML formats [11]. So it is an effective solution for us to convert GPS information to KML FILE that Google Earth could identify.

3.1 Data Organization

With a view to software designer, data organization in the vehicle positioning monitoring system is always a difficult and hot issue, and it is also a core problem concerning sound and stable system functions. Relevant vehicle positioning monitoring data mainly includes the following three categories [12]：first, base map data, including administrative divisions, residential areas, gas stations, arterial streets, etc; second, road network data, including road centerline network diagrams, scissors crossing and other road network data; at last, vehicle monitoring and navigation attribute data, including vehicle location, driving route, distance, direction, speed, length of stay in one position, history data in vehicle operation, etc; However, relational database system can better solve parse and storage of vehicle positioning monitoring data and real-time data transmission, core program flow chart shown in Fig. 4.

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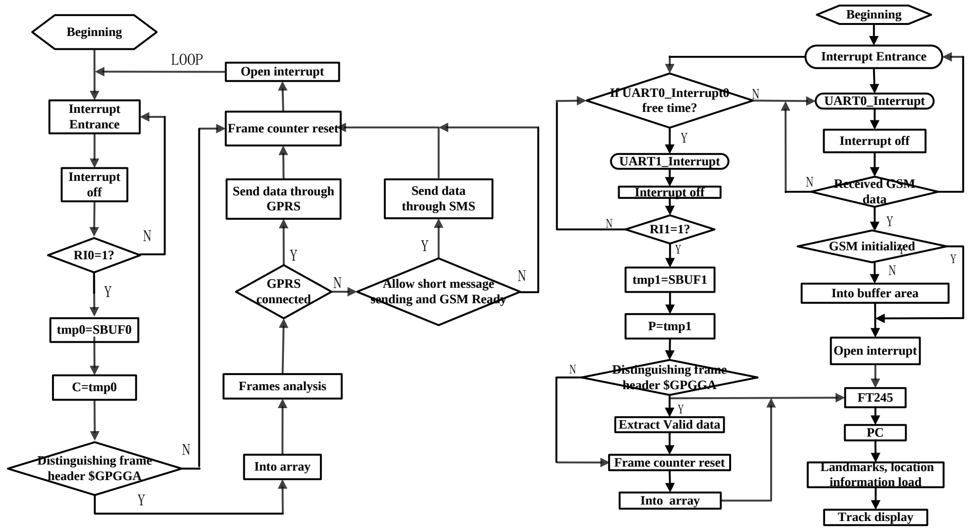

Figure.4. Core Program Flow Chart

Truck/ship-borne positioning terminal receives NMEA0183 protocol string positioning information that exist in many format[such as $GPGGA, $GPRMC, $GPGSA, $GPVTG and so on] from the GPS receiver[13], while, the information we need such as latitude, longitude, elevation, time be stored in something that begin with '$GPGGA' ,the detail: $ GPGGA, UTC time, latitude, North / South latitude, longitude, East / West longitude, quality factor, the number of satellites, the level precision, high degree of antenna, age of differential GPS data, the number of differential base station, etc. The extract algorithm of latitude as follows:

```
AfxExtractSubString(latitude,(LPCTSTR)GPGGA,3,',');
strdu=latitude.Mid(0,2);
strfen1=latitude.Mid(2,2);
strfen2=latitude.Mid(5,5);
longfen=1000000*atol(sfen1)/60.0+1000000*atol(strfen260.0;
ltoa(longfen,strfen,10);
strfen.Format("%s",str);
int z=strlen(strfen);
while(z<6)
{
strfen="0"+strfen;
z++;
}
z=strlen(strdu);
while(z<3)
{
sdu="0"+sdu;
z++;
}
latitude=strdu+"."+strfen;
```

Note: the similar algorithm could be adopted when extract longitude, elevation, time.

In this article, we turned to the text-based data via the short message service enabled by the standard cellular phone communications networks: GSM (Global System for Mobile Communication)/GPRS(General Packed Radio Service) networks, which provides a low-cost, effective solution in area with an extensive coverage of mobile phone networks and has overcome the drawbacks of voice radio-based solutions[14]. After completing initialization，we must send AT instruction to check the GSM networks and then set short messaging mode when receive corresponding answers through AT + CMGF: if the result is zero means PDU mode and others TEXT，and set the phone number by sending AT + CMGS, while, we can edit short message

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when receive a response '>' and end the operation with the hexadecimal string 0x1A. The relevant algorithm of data transmission as follows:

```
send_at();
delayns(1);
send_cmgf();
delayns(1);
send_cmgs();
delayns(1);
for(ii=0;ii<tempreadcount;ii++)
{
while ((IFG1 & UTXIFG0) ==0);
TXBUF0 =newsdata[ii];
}
delayns(2);
while ((IFG1 & UTXIFG0) == 0);
TXBUF0 =0x0D;
delayns(2);
while ((IFG1 & UTXIFG0) == 0);
TXBUF0 =0x1A;
```

In our experiment we send short messages in the form of TEXT over GSM, each tracking message recorded the time, the position (latitudinal and longitudinal coordinates), the heading direction, and the activity status of the truck. Given the GSM network server available, the data updating frequency in our experiment was about one message every 30 s to 1 min, which was considered adequate for the current concrete truck tracking application. One short message contains up to 160 letters, which is sufficient to relay the current location and delivery status information of a mixer truck.

3.2 Track access

We obtains the raw GPS data in WGS-84 coordinate system from truck/ship-borne positioning terminal, while our geographic data selects BJ-54 coordinate system, and these two coordinates not only the origin of the coordinate system is inconsistent, but also the corresponding axes are not parallel to the system application, so it is integrant to execute coordinate transformation. This study introduce the method of transformation of seven-parameter as follows[14]：

1) geodetic coordinate system transform to rectangular coordinate system of WGS-8coordinate system:

Assuming geodetic coordinate is (B, L, H), and rectangular coordinate is (X,Y,Z),we have

$$X = (N + H)\cos B \sin L$$
$$Y = (N + H)\cos B \sin L$$
$$Z = [N(1 - e^2) + H]\sin B$$

Where L, B, H is longitudinal, latitudinal and height respectively,

and $N = a/(1 - e^2 \sin^2 B)^{1/2}$,

$$e^2 = (a^2 - b^2)/a^2$$

2) Obtain transformation parameters with the method of seven-parameter:

$$\begin{bmatrix} X_{Di} \\ Y_{Di} \\ Z_{Di} \end{bmatrix} = \begin{bmatrix} \Delta X \\ \Delta Y \\ \Delta Z \end{bmatrix} + (1+k)\begin{bmatrix} X_{Gi} \\ Y_{Gi} \\ Z_{Gi} \end{bmatrix} + \begin{bmatrix} 0 & \varepsilon_Z & -\varepsilon_Y \\ -\varepsilon_Z & 0 & \varepsilon_X \\ \varepsilon_Y & \varepsilon_X & 0 \end{bmatrix}\begin{bmatrix} X_{Gi} \\ Y_{Gi} \\ Z_{Gi} \end{bmatrix}$$

Where $[(\Delta X, \Delta Y, \Delta Z)]$ is the translation transformation parameter, and $\varepsilon_X, \varepsilon_Y, \varepsilon_Z$ are the rotation transformation parameter.

3) Rectangular coordinate system of WGS-84 coordinate system transform to geodetic coordinate system of BJ-54 coordinate system:

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$$L = \arctan(Y/X)$$
$$B = \arctan\left\{Z(N+H)/\left[\left(X^2+Y^2\right)^{1/2}\left(N\left(1-e^2\right)+H\right)\right]\right\}$$
$$H = Z/\sin B - N\left(1-e^2\right)$$

Track access is pivotal to monitoring the motion of hazardous goods and thereby allowing intervention teams to react immediately with maximum safety delivery status of a concrete truck, which is completed through Google Earth with map file[such as North University map]. While, two kinds of expansion interfaces be provides in Google Earth[15]: API (COM) and KML (keyhole markup language) file that we select in our research, which is a file based on XML syntax that describe and save geographic information (such as points, lines, images, polygons, and model, etc.).Thereby KML file be used in exchanging for geographic data in Google Earth map browser，and defining some ways that geographic data can be showed. Its applications: ① designate locatio icons and annotation; ②create a differe perspective position for each geographical features; ③ stacked images on Earth; ④specify the style of geographical features; ⑤mpile HTML that describe geographical features , hyperlinks and embedded images included; ⑥dynamically access and modify for KML files；⑦3D display. Table 1 shows some class used in our research [16]:

Table 1

keywords	Value(s)
IApplicationGE	Entry classes. calls to other classes with it
IcameraInfoGE	Camera classes. adjust the viewing of the current view
IfeatureGE	Element class. control the properties of an element;
IFeatureCollectionGE	Elements collection class. get further elements;
IPointOnTerrainGE	Geography fiducial mark class. gains the screen geographic coordinate;
IViewExtentsGE	View Window class. check the current window size;
XmlTextWriter	Text class. Writes the inward flow, document or the string of character the XML data through this kind;

4. EXPERIMENTAL RESULTS ANALYSIS

In a delivery trip to north university, we placed the truck/ship-borne positioning terminal at a car, and send short message with a phone whose number is 15513044892 by GSM module to the positioning monitoring terminal, and then we obtain the positioning information shown in Fig. 7, in which the green triangle represent the location of the car carrying the positioning monitoring terminal, we gain some accurate spatial location: longitude(112°26'48.4812")，latitude (38°0'57.3078")，elevation（846.2km）.

While the display of the car shown as Fig. 8, in which blue five-pointed star present the car, that is to say, truck/ship-borne positioning terminal, and the red five-pointed star signify the positioning monitoring terminal，certainly，the blue line is the track of car. Besides, some blue text[such as longitude (112°26.71110')，latitude (38°00.87460')，elevation（823.89km）]appears on the right of the figure, which is the accurate spatial location of the car, similarly, the red

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text[such as longitude (112°26.71560'), latitude (38°00.87322'), elevation（826.9km）] means the spatial location of the positioning monitoring terminal.

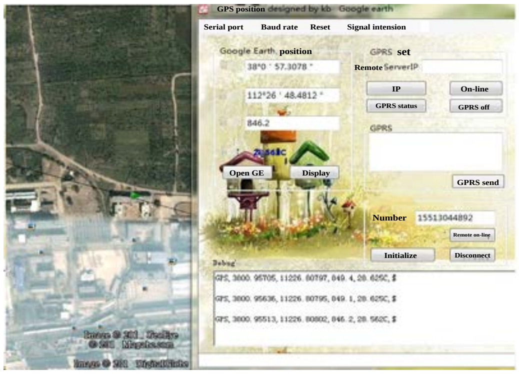

Figure.7 The Positioning Display Software Interface Schematic Diagram

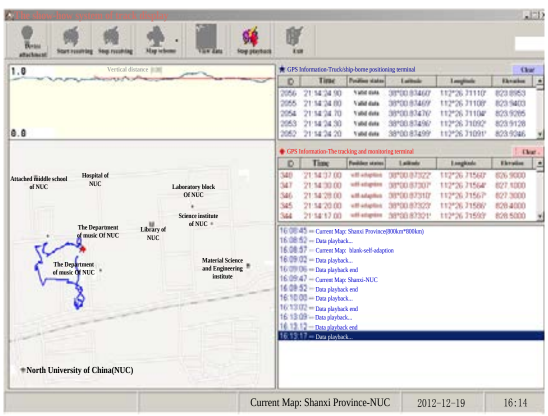

Figure.8 Track Software Interface Schematic

5. CONCLUSION

With the development of the transportation of hazardous materials，in this paper, we elaborate a high-precision, fast and accurate GPS vehicle positioning monitoring system based on multiple networks. Practice shows that the application of GSM network, mobile GIS and GPS in vehicle positioning monitoring system has improved the accuracy of spatial location of moving vehicles, and has helped visual display of located objects, which has also verified the feasibility to integrate GSM network and Google Earth for mobile location services. It has important theoretical and practical value to further study the algorithm and avoid or reduce occurrence of accidents caused by hazardous chemicals and improve the security and reliability of hazardous chemicals transportation further study the algorithm.

REFERENCES

[1] E. Planas, E. Pastor, F. Presutto, J. Tixier. Results of the MITRA project: Monitoring and intervention for the transportation of dangerous goods. Journal of Hazardous Materials,152 (2008) 516–526.

[2] Joanne Ellis. Analysis of accidents and incidents occurring during transport of packaged dangerous goods by sea. Safety Science, 49 (2011) 1231–1237

[3] Roberto Bubbico, Sergio Di Cave, Barbara Mazzarotta, Barbara Silvetti. Preliminary study on the transport of hazardous materials through tunnels. Accident Analysis and Prevention, 41 (2009) 1199–1205

[4] Christophe Adrados, Irène Girard, Jean-Paul Gendner, Georges Janeau. Global Positioning System (GPS) location accuracy improvement due to Selective Availability removal, C. R. Biologies 325 (2002) 165–170.

[5] G. Mintsis, S. Basbas, P. Papaioannou, C. Taxiltaris, I.N. Tziavos. Applications of GPS technology in the land transportation system. European Journal of Operational Research, 152 (2004) 399–409.

[6] Ming Lu, Wu Chen, Xuesong Shen, Hoi-Ching Lam, Jianye Liu, Positioning and tracking construction vehicles in highly dense urban areas and building construction sites. Automation in Construction, 16 (2007) 647–656.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

[7] Adam Theiss, David C. Yen, Cheng-Yuan Ku. Global Positioning Systems: an analysis of applications, current development and future implementations. Computer Standards & Interfaces,27 (2005) 89–100.

[8] He Rongyu , Zhao Guolei, Chang Chaowen, Xie Hui, Qin Xi, Qin Zheng. A PK-SIM card based end-to-end security framework for SMS. Computer Standards & Interfaces, 31 (2009) 629–641

[9] Zechun Huang, Dingfa Huang,Zhu Xu ,Zhigen Xu. GPS Vehicle Positioning Monitoring System Integrated with CORS and Mobile GIS. Procedia Environmental Sciences, 10 (2011) 2498 – 2504.

[10] Xiaoying Yang, Geng-Ming Jiang, Xingzhang Luo, Zheng Zheng. Preliminary mapping of high-resolution rural population distribution based on imagery from Google Earth: A case study in the Lake Tai basin, eastern China. Applied Geography, 32 (2012) 221e227.

[11] R Galas and W. Kiihler. A Binary Exchange Format for GPS Data. Phys. Chem. Earth,2001.

[12] AijunChen, GregoryLeptoukh, StevenKempler, ChristopherLynnes, Andery Savtchenko, DenisNadeau,JohnFarley. Visualization of A-Train vertical profiles using GoogleEarth. Computers & Geosciences ,35 (2009) 419–427.

[13] Simson Garfinkel. Digital forensics XML and the DFXML toolset. Digital Investigation, 8 (2012) 161–174

[14] Declan G.DePaor, StevenJ.Whitmeyer. Geological and geophysical modeling on virtual globes using KML, COLLADA, and Javascript. Computers & Geosciences, 37 (2011) 100–110.

[15] Lisa M.Ballagh, BruceH.Raup, RuthE.Duerr, SiriJodhaS.Khalsa, ChristopherHelm, Doug Fowler, AmrutaGupte. Representing scientific data sets in KML: Methods and challenges. Computers & Geosciences, 37 (2011) 57–64.

[16] E. J. KANSA. Local, Point-Wise Rotational Transformations of the Conservation Equations into Stream-Wise Coordinates. Computers and Mathematics with Applications ,43 (2002) 501-511.