Satellite Location & Navigation of Vehicles on the International Transport Corridor of Iran, Russia and India

AA. Alesheikh[1], A. S. Niaraki[2], M. Varshosaz[3], H. Helali[4]
Dept. of Geodesy & Geomatics Eng.
K.N. Toosi University of Technology
Vali_Asr St., Tehran, Iran, 19697
[1] Assistant Professor Email: ali_alesheikh@hotmail.com
[2] Graduate Student Email: a_sadeghi313@yahoo.com
[3] Assistant Professor, Email: varshosaz@ce.knt.ac.ir
[4] Ph.D. Student, Email: hhelali@yahoo.com

ABSTRACT

A key factor in improving the economical life of all countries is transportation. The global telecommunications and information technologies are offering powerful options for solving what seem to be intractable problems of congestion, traffic management, and the environmental impact of surface transportation. Satellite location and navigation of vehicles play a vitally important role in the management of vehicle transportation.

The main object of this paper is to assess the current technologies related to the vehicle navigation. This paper also describes the design and implementation phases of a satellite location and navigation system for the transit vehicle passing through the International (North-South) Transport Corridor of Iran. Implementation phase has been considered as a process rather than a step that starts with feasibility study and ends in system use and maintenance.

It is expected that the project improves the transit, and as such the economy of the involved countries. Researches are initiated to quantify the benefits of this project. More study has been planned to link the results of this project to the ports network so that the ships lapse time will be minimized.

Key Words: Satellite Positioning, GPS, Tracking, Web GIS

1 Introduction

Nowadays, transportation system plays a vitally important role in the economics improvements of all countries. Modern life demands growing mobility. For goods delivery, it is secured through ever increasing use of trucks. The resulting burden on a transport infrastructure that is already heavily stretched is multiplying. Despite major investment on building new road infrastructures, traffic congestion, and delay factors continue to rise. Innovative efforts are clearly a must. Among them is the concept and practice of Vehicle Location and Navigation (VLN) system. This innovation can open up new ways of achieving sustainable transportation in the communications and information society (Chen & Miles 1999).

The world consideration to the subject of road transportation in Asia and Pacific has begun since 1960. In the late 1980, the world was witnessing the collapse of the centralized economic regimes of the Soviet Union. These issues exposed strong needs for a coordinated plan in the area of transportation in Asia and Europe. As such, several agreements have been signed to increase trade volumes, among them are; ALTID (Asia Land Transportation Infrastructure Development) that is the encouraged and supported by the UN (United Nations); ESCAP (Economics-Social Commission for Asia and Pacific) commission; TRACECA (Transport Corridor Europe Caucasus Asia); and lastly the International (North-South) Transport Corridor (INSTC) of Iran, Russia, and India that was signed by the transportation ministers of the involved countries in September 2000.

Based on the INSTC agreement, Iranian Transportation and Terminal Organization (TTO) was mandated for the optimum management of transit trucks. In late 2001, K.N. Toosi University of Technology has signed an agreement with TTO to track the trucks on the INSTC interactively.

A GPS receiver has been mounted on a vehicle to determine the geographical coordinates of the truck. An electronic board was built to transmit the coordinates of the truck to the TTO's central office in Tehran. A web GIS was then initiated to load and distribute the spatial and non-spatial information of the truck on the INSTC to the TTO's Internet.

A feasibility study and system investigation has been carried out to document the current system infrastructure, to identify the possible improvements, and to determine the required data for satellite navigation. Once the needs analysis phase has been completed, plan was made to evaluate the available software and hardware. A conceptual data model has been designed and efforts were made to build up the database.

2 Enabling Technology

The ability to locate and navigate vehicles, whether real-time or with static updates, has long been hampered by the lack of sufficient communications and sensor technology. However, the recent advent of multiple layered communication strategies using advanced cellular and satellites has enabled the creation of worldwide real-time tracking applications. Sensor technology has also dramatically increased in capability while decreasing in size thus expanding the types of possible tracking applications. While some tracking technology remains expensive, ever-increasing coverage areas and increased usage will quickly drive down the price of the enabling technology. As Figure 1 shows this system includes data gathering device, communication method and base station.

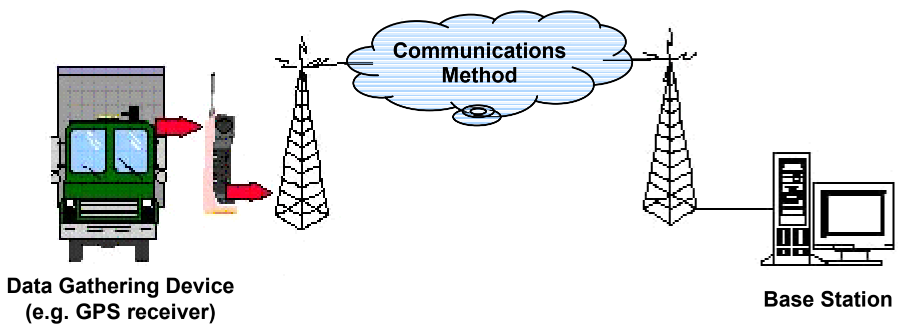

Figure 1: Tracking System

2.1 Global Positioning System

GPS (Global Positioning System) is a form of information technology that uses systems of hardware and software, as well as information (time and ephemeris) transmitted from satellites to provide locations information to users (Figure 2). This derived information (time, position, and velocity) may then be combined with other systems such as communications devices to be sent to a central station for further processing.

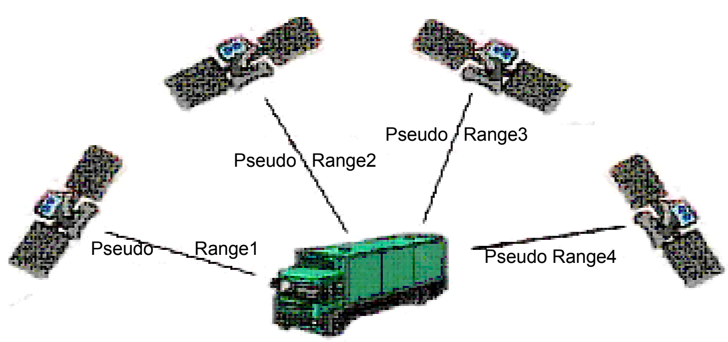

Figure 2: GPS is a form of information technology

The first GPS applications began by answering the question "Where am I?" and later, with the addition of communications, were able to answer "Where are you?" type questions. Most recently, GPS is being used to answer a "Where is it?" type question for applications in the tracking of assets. "Where am I?" applications involve the most visible kinds of GPS equipment such as handheld receivers used by hikers, drivers, pilots, and surveyors. The user provides information, such as latitude, longitude, altitude, and time, from a GPS receiver for further action. The information may be translated into more easily understood forms, such as a position relative to an existing map, or used to provide information such as distances to user-defined "waypoints" (e.g., positions that are specifically identified by the user). "Where are you?" applications are those that have GPS information for multiple users communicated to another party. For example, a manager of a trucking fleet can use GPS and mobile phone communications to stay in touch with the drivers.

"Where is it?" applications are ones in which GPS is used to track assets, such as cargo shipments, or manage data packets in dense information networks. GPS works by timing how long it takes coded radio signals to reach the earth from its satellites. A receiver does this by generating a set of codes that are identical to those being transmitted by the system's satellites. It then calculates the time delay between its codes and the codes received from the GPS satellites by determining how far it has to shift its own codes to match those transmitted by the satellites. This travel time is then multiplied by the speed of light to determine the receiver's distance to the satellites. A GPS receiver could, in theory, calculate its three-dimensional position by measuring its distance from three different satellites, but in practice a fourth satellite is necessary because there is timing offset between the clocks in a receiver and those in a satellite. The fourth measurement allows a receiver's computer to solve for the timing offset and eliminate it from the navigation solution. For many applications, greater accuracy is needed than is possible with GPS alone (e.g. positioning accuracy of a few meters or even centimeters). Differential GPS (DGPS) is a method of operating GPS that allows a user to obtain extremely high accuracy (Alesheikh & Niaraki, 2001a).

2.2 Communication Media

For most vehicle navigation applications, four communication media types can support communications requirements between the GPS and the base station. They are Wire Line (fixed-to-fixed), wide area wireless (fixed-to-mobile), dedicated short-range communications (fixed-to-mobile), and vehicle-to-vehicle (mobile-to-mobile). Each application could have different communications needs that match the particular requirements for frequency, distance, data size, and so forth (Niaraki AS, 2001).

2.2.1 Wire Line. There are numerous Wire Line technology options for fixed-to-fixed communications requirements. For example, traffic management applications can use leased or owned twisted wire pairs, coaxial cable, or fiber optics to gather information and to monitor and control traffic surveillance sensors, traffic signals, changeable message signs, and so forth. In other applications, it may be more advantageous to use terrestrial microwave links, spread spectrum radio, or an area radio network to provide communications between a management center and remote controllers. Although these are wireless communications technologies, they are used to provide fixed-to-fixed communications in the examples cited; consequently they are often referred to as Wire Line communications media. Wire Line network options include private networks, public shared networks, or a mixture of the two. Private network technologies include Ethernet, Fiber Distributed Data Interface (FDDI), Synchronous Optical Network (SONET), and Asynchronous Transfer Mode (ATM). Public shared network technologies include leased analog lines, leased digital lines, frame relay, Integrated Services Digital Network (ISDN), metropolitan Ethernet, Internet, and Switched Multimegabit Data Service (SMDS).

2.2.2 Wide Area Wireless. There are two distinct categories of wireless communications based on range and area of coverage wide area and short range. Wide area wireless (fixed-to-mobile) communications are suited for services and applications where information is disseminated to users who are not located near the source of transmission and who require seamless coverage. Wide area wireless communications are further differentiated on whether they are one-way or two-way. An example of a one-way broadcast transmission is the traffic reports we currently receive over AM or FM radio. A mobile traveler who requests and receives current traffic information from an information service provider is an example of two-way communications. Two-way wide area wireless technologies include Global System for Mobile Communications (GSM), Special Mobile Radio (SMR), Enhanced Special Mobile Radio (ESMR), Personal Communications System (PCS), ARDIS, RAM, Geotek, 220 MHz, Metricom, Tetherless Access Ltd. (TAL), two-way paging, and Cellular Digital Packet Data (CDPD). CDPD, one of the more popular technologies, allows TCP/IP data Transmission over analog cellular systems and takes advantage of unused cellular spectrum. One-way broadcast communication technologies include AM sub carrier, FM sub carrier, and Highway Advisory Radio (HAR). FM sub carrier systems assessed included Sub carrier Traffic Information Channel (STIC), Data Radio Channel (DARC), High Speed FM Sub carrier Data System (HSDS), RBDS, ALERT, and SCA.

2.2.1 Short Range Wireless. Short Range Wireless communications are concerned with information transfer that is of a localized interest. There are two types of short-range wireless communications, vehicle-to-vehicle and Dedicated Short-range Communications (DSRC). Vehicle-to-vehicle (mobile-to-mobile) short-range wireless communications are required to support the Automated Highway System (AHS) and, most likely, intersection collision avoidance implementations. Appropriate applications for DSRC (fixed-to-mobile) include toll collection, parking fee collection, roadside safety inspections, credential checks, in-vehicle signing, intersection collision avoidance, and selected AHS communications (e.g., safety checks, access authorization, and system status updates). Other applicable technologies include radio frequency (RF) and Infrared (IR) short-range wireless beacon/tag communications for the DSRC requirement.

2.3 Satellite Systems

Satellite communication is line-of-sight from space and, as such, provides excellent coverage for outdoors. However, satellite systems provide little or no coverage in tunnels or dense forests. There is an array of satellite systems suitable for tracking applications. These include a variety of little (data only) and big (voice and data) low-earth-orbit (LEO) systems, as well as more conventional medium-earth-orbit (MEO) and geosynchronous orbit (GEO) systems. Many of these systems are not yet deployed; however, they are projected to be in service within the next few years. These systems include ORBCOMM, STARSYS, VITASAT, MSAT, Constellation, GLOBALSTAR, IRIDIUM, TELEDESIC, Ellipse, Odyssey, Skytel, VSAT, and OmniTRACS. Availability and cost of the service, coupled with the cost of the terminals, are common issues that must be addressed in fielding a tracking application (Niaraki 2001b).

2.4 Web GIS

With the enabling information technology, disseminating positional information through the Internet became an enforcing condition for a successful vehicle location and navigation (Helali, 2001). Internet Map Server (IMS) applications allow GIS database custodians to easily make their spatial data accessible through a web browser interface to end-users. High-speed corporate intranets make an ideal network for distributing data in this manner, given the fact that bandwidth requirements can be high. Making data available to the entire world is certainly feasible and any organization that has a public website can certainly add an IMS without opening up too many additional security holes.

For a working IMS, software requires two components to function. A geospatial data processing engine that runs on the server side as a service, Servlet or Common Gateway Interface (CGI) application, and processes the raw spatial data into a map and a standard web server that manages the incoming requests and replies with the proper map data back to the client side browser or application window. The end product is either a JPEG or GIF image or vector, which is transmitted back to the client browser or a stream of data that is interpreted by a plug-in to the client browser. IMS that transmit back an image have a limited capability that does not extend much beyond pan, zoom, and basic vector attribute query. The feature streaming IMS requires a downloadable plug-in, but allows for advanced buffer, query, labeling and sub setting operations to be performed. Some IMS sites offer both a plug-in and a simple HTML version, which is nice for plug-in weary surfers.

3 Vehicle Location and Navigation Development Cycle

Developing a Web GIS for vehicle location and navigation is more than simply buying the enabling technologies. To have a successful implementation the following strategies were devised (Figure 3). The strategy is described in terms of 6 major activities starting with the feasibility study and ending with on-going review and maintenance of the VLN system.

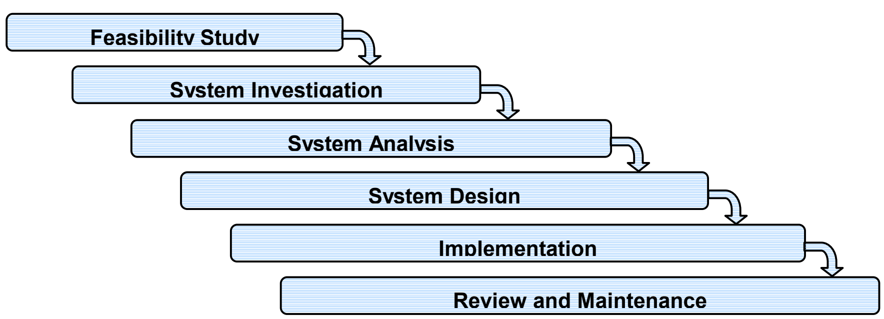

Figure 3: Web GIS Development Process for VLN

3.1 Feasibility Study

The purpose of this step was to determine whether the existing system could be improved. It concentrates on issues of efficiency and effectiveness. With respect to the enabling technologies an estimate of cost/benefit is determined.

3.2 System Investigation

The object of the project is to determine the position of trucks on the Iranian roads and disseminate the information through the Internet, so that constituents can easily access the data. This step has been performed through interviewing potential users, and produced two critical pieces of information:

- A list of functions that is needed. The required functions are the basic visualization functions such as Pan, Zoom, and more advanced functions such as object identification. User can use these functions to view road information, and peripheral constructs such as gas stations and rest areas.
- A master list of available/needed geographic data. TTO has captured several layers of road information using GPS. In this project, only 25 layers of information have been used that includes; police station, restaurants, gas station, mosques, etc.

The information gained in the system investigation activity went directly into the system analysis phase.

3.3 System Analysis

Once the required data has been identified, the challenges have been identified to improve the current system. A data dictionary has been created in this step. The primary purpose of this phase of the development process was to specify "how" the system performs the required applications.

Selecting suitable software is an important step in a successful implementation. Software was evaluated on functionality and performance, and independent of the hardware and operating system. The VLN system requires specific hardware configuration. Since the volume of transferred data is huge, the speed of Internet connection is vitally important.

3.4 System Design

System design involved defining how graphics will be symbolized (i.e., color, weight, size, symbols, etc.), how graphics files will be structured, and what management and security restrictions will be imposed on file access. In this step the output of the new system, the inputs and the transformation of the inputs to outputs is specified.

3.5 System implementation

The initial System Analysis contained some applications of a complex nature. However, the majority of initial applications was straightforward, and can be implemented using the basic functionality that is part of the enabling software (e.g., display). The more complex applications were not supported by the basic functions of Web GIS but have been programmed. Ease of use, user-friendliness, and reducing the volume of data transfer were the critical issues considered in the development.

3.6 Review And Maintenance

The final step in web GIS implementation was to put the system to use. With system integration and testing completed and all applications available for use, the system was released to users. Two activities were in place:

- User support and service, in which new applications will be determined, and
- System maintenance (database, hardware, software), in which the Web GIS must run smoothly

4 Conclusions

This paper analysis the current technologies related to vehicle location and navigation. Three major parts have been identified for a running system: GPS, communication Media and Web GIS. This paper also proposes a development process for a successful Vehicle Location and Navigation system. VLN development is more than buying appropriate software and hardware. In order to succeed, the implementation phase must be considered as a process rather than a step. The process starts with feasibility study and ending in system review and maintenance.

It is expected that with full release of the system: Transportation managers can guide the trucks to where and when it is required.

References

Alesheikh AA, Niaraki AS (2001) *Monitoring And Tracking Fleet Vehicles On Silk Road*. Proceeding of the Digital Earth 2001 Conference, Fredericton, NB, Canada

Chen K, Miles JC (1999) *ITS Handbook 2000*. Recommendations from the World Road Association (PIARC), Artech House, Boston, London

Helali H (2001) *Design and Implementation of a Web GIS for the City of Tehran*. MSc thesis, Department Of Geodesy And Geomatics Engineering K.N.Toosi University Of Technology, Tehran, Iran

Niaraki AS (2001a) *Consider tracking systems*. Seminar of Master degree of GIS in Dept. of Geodesy and Geomatics Engineering, K.N.Toosi University of Technology, Tehran, Iran

Niaraki AS (2001b) *Tracking and Communication system*. Proceeding of the GPS80 Conference, Science & Industry University, Tehran, Iran