

Vehicle Tracking in the Process of Transport of Dangerous Goods GPS/GSM Technology

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Abstract: In the paper it has reviewed the monitoring of vehicles in the transport of hazardous substances based on the using of GPS/GSM technology. The basic principles of the GPS concept and hardware have been exhibited which are implemented in locating the vehicle. They have also identified the locating techniques underlying the monitoring process. It has presented an active system for monitoring parameters of the means of transport.

Key words: GPS/GSM, risk, dangerous goods, hazardous materials, transportation.

1. Introduction

Modern trends in the development of transport technologies in the foreground set complex requirements related to the process of monitoring vehicles. The parameters which define accompanied vehicle are referred to the current position, the speed, the route of movement points, stop time and others. The monitoring process is implemented using the vehicle communication system based on wireless transmission of signals presents behavior parameters of the vehicle. The system of monitoring in the transport process was initially developed in terms of security during the 1980s, to mitigate risks in the transport of certain hazardous materials. This concept has been successfully implemented to other requirements in order to increase the utilization of the Continued resources. success of wireless communication and a favorable balance between system performance monitoring and prices opened a wide range of applications to geo-positioning of vehicles [1]. This has created a new infrastructure to the control of traffic flows, which was enabled by mobile phone online service [2]. When considering the issue of vehicle tracking, special attention is paid to the accuracy of the positioning. Using GSM and GPS technology allows the system to monitor the vehicle and provides the most current information of travelling. This system finds its application in real-time traffic control [3, 4].

GPS tracking system is one of the fastest growing technology worldwide [5]. Today, GPS is used in trucks, cars, ambulance and police vehicles on the roads of developed countries. All existing technologies support monitoring of the city vehicle but do not provide the safety of vehicles. Development and application of GPS vehicle tracking allows companies to monitor their vehicles in real time and provides alarm reporting system in the event of accidents [6]. Integrated monitoring system supported by GPS and GSM technician servicing, is characterized by four basic parameters: location information, real-time monitoring, status of the monitored object and communication activities within the system. GPS based its work on information obtained on the geo-position and time data from global positioned satellites, how this system got its name [7]. GSM is a popular type of mobile telephone system, whose share in the global mobile phone market is about 80%. The purpose of this system is to send information about the current parameters of followed vehicles in the center where they are

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processed and thus get the specific measures, if different from provided. This opened up the possibility of control process automation in real time. The system of these performances opens up wide possibilities of applications in the field of risk control activities in transportation of hazardous materials.

2. GPS Monitoring Concept

The principle of GPS tracking concept is based on the using of techniques "trilateration" [5] and implies that the receiver has the ability to determine their position at any point on Earth, measuring the time it takes for signals from different satellites to reach them. The basic idea of the satellite monitoring is to determine the distance between the satellites and the current location of the user. Based on the known distance between the four satellites, the position monitoring is unambiguously defined with exactly one position on the Earth's surface (Figs. 1 and 2).



Fig. 1 Assist GPS satellites determining the position.



Fig. 2 Locating users on the Earth's surface.

Positioning accuracy depends on the accuracy of measuring distance, as well as precision positioning satellites. In addition to the hardware components, an important role in achieving the positioning accuracy has GPS software, through which is registered any defect signal and the time difference between it and the GPS satellite network, using information about signals from four separate satellites.

Each GPS satellite broadcasts two types of data: almanac and ephemeris. The first type of data is relating to weather and status information about the satellite. The second type of data relates to the very precise orbital information of a satellite. Signal representing the almanac data incorporate visibility of satellites turning on the receiver based on the stored information about position and time, while ephemeris signals are intended to determine the exact position of the receiver.

Each GPS satellite is constantly updated according to the information obtained by continuous measuring from Earth. Weather information consists of the flow of data acquisition (C/A code), pseudo—random numbers that are repeated every millisecond. GPS receiver (Fig. 3) calculates its position based on the information about the time. It compares the time information with the internal clock based on the crystal oscillator, and then generates the C/A code.

This mechanism is characterized by high timing accuracy. Error of 1 ms gives a deviation of 30 m, while under optimal conditions, the object can be identified with the deviation of 3 m. GPS is set to record data every thirty seconds along the route [8].

For the process of transfer of codes and navigation message from the satellite to the receiver on the Earth's surface, it is necessary to perform the modulation of the signal at the carrier frequency. For this purpose, the two frequencies: L1 from 1,575.42 MHz and L2 of 1,227.6 MHz [9, 10]. Modulation is the process of signal processing that signal information (containing information around some size) integrates (modulate) the transmission signal (Fig. 4).



Fig. 3 GPS receiver: external appearance and structure.



Fig. 4 The modulation of the signal at the carrier frequency.

This amplitude signal carrier frequency changes in proportion to signal of useful information. Portable signal has a higher frequency, which improves the dispersion wave properties of transmission medium [11].

Modulated signal which registers the receiver must be demodulated in order to identify the source signal (Fig. 12). In the communication system modulator is an integral part of the channel encoder, a demodulator channel decoder. Modulator and demodulator represent modem which modulates the analog signal to encode digital information, and vice versa (Fig. 5).

3. The Role of the GSM System in the Process of Monitoring

GSM (global system for mobile communications) is a generally accepted standard for digital mobile communications. The functioning of this system is made possible by using of GSM modems (Fig. 13), which is a wireless type and supported by the GSM wireless network [12]. This type of modem, unlike



Fig. 5 Demodulation carrier signal.



Fig. 6 GSM modem.

conventional dial-up model, sends and receives messages via radio waves [13]. GSM modem is a specialized type of modem that accepts the subscriber identity module (SIM card) and works in the same way as a mobile phone. GSM uses the process that is known as switching channels. This communication method allows to determine the constant flow trajectory of digital data connected between the two devices.

GSM network consists of three main systems:

- SS (switching system) (broadband network);
- BSS (base station subsystem);
- The MS (mobile station).

OMC is operations center in which it is done processing and storing data. Implementation of the OMC relates to a support system that represents a functional unit from the operator monitor and control system. The purpose of the system (network) is a cost-effective support for centralized, regional and local activities in terms of operational monitoring and maintenance system within the GSM network (PSTN). BSS (base station system) consists of a subsystem BSC and transmits the wireless signal transmission (Fig. 7).

4. Monitoring of Transport of Hazardous Substances

In this chapter attention will be focused on techniques for monitoring vehicles in the transportation process, with special emphasis on the transport of dangerous goods. In terms of identifying the position of the vehicle, three techniques have been developed for monitoring, and are based on the following principles:

- Point indicator;
- Vector indicator;
- Segment indicator.

Point monitoring indicator (Fig. 8) implies that each subsequent (future) position of the vehicle is identical to its last registered position. Updating of information with a certain degree of accuracy can be performed when previously registered position of the vehicle deviates from the current GPS position. Points representing the updated positions, thin line defines the actual path of movement, while the deviations are given by a dotted line in relation to the full line representing the profile of the road.

Vector monitoring indicator is based on the assumption that any further or future position of the vehicle can present linear-as a function of time, i.e. with an initial position and velocity vector. Specific starting position and velocity values are taken from the GPS receiver in the previous process of updating vehicle data. On this basis, it can be concluded that the previous monitoring approach (point concept) is a special case of the indicator vector, when the velocity vector is identical to zero-vector. GPS receiver determines the parameters relating to the intensity of the speed and direction of movement of the vehicle on the basis which integrates velocity vector. At each point of data update, velocity vector must be tangent to the curve that represents the actual path of movement (Fig. 9).

Segment monitoring indicator is based on the knowledge of the road network in which the vehicle is moving. In this regard, it is necessary to have available a digital display of the road network. The information obtained by the vehicle used for locating work times presented as a semi lines along which the vehicle is moving. This method of monitoring, implies that any further position of the vehicle defines moving with constant velocity along the identified segment.



Fig. 7 Structure of the GSM network signal transmission.



Fig. 8 Point indicator tracking of vehicles.



Fig. 9 Vector vehicle tracking indicator.

This speed is obtained by registering for the previous updated vehicle position (Fig. 10).

A comparison result shows that depending on the applied techniques of monitoring, the average time update varies between 10 and 115 seconds (Fig. 11). Segment indicator monitoring, which forms the shape of the route using the acceleration profiles, gives the best results.

Monitoring systems vehicle by its type can be active or passive character. Active monitoring systems have been developed for the transmission of data on the parameters of the vehicle in real time, via the satellite network, the computer processing center. The original vehicle tracking systems were passive character, whose work is based on hardware located in the vehicle and which records all the information on the position, speed and other manipulative activities related to transportation. Insight into these data is done upon arrival of the vehicle at a specific location or



Fig. 10 Segment indicator tracking of vehicles.



Fig. 11 Comparison of performance monitoring technique.

after returning to the starting location. Although passive monitoring system is preventively effected on some irregularities during driving (e.g., speeding, opening cargo, etc.) they are in many cases unable to meet the complex requirements of the user. Therefore, active systems are essential, especially if one takes into account high-risk vehicles (e.g. transport of valuables and money), where there is the possibility of abduction as well as during the transport of dangerous goods (toxic and explosive substances) when accidental events can have catastrophic consequences on the road (Fig. 12).

The role of active monitoring system during transport has a twofold effect, namely:

• registration behavior during the process of transport and

• timely reaction to unforeseen situations in order to eliminate or mitigate their consequences.

Most tracking systems using today to determine the geographic location of the vehicle are based on the concept of AVL (automatic vehicle location) [14]. Locating is done using GPS, while the mechanism of information transfer is implemented by mobile connection with the satellite. The current location of transport is defined via satellites that send signals to a receiver mounted on the vehicle. Information relating to the GPS position and other information about the behavior of the vehicle (speed, etc.) via GSM modem is sent to the base station, and then to a local service provider which then that signal with the information forwarded to an operations center for further treatment and monitoring vehicle (Fig. 13). This process can be



Fig. 12 Leakage of hazardous materials from an overturned tanker.



Fig. 13 The concept of GPS/GSM vehicle tracking.

performed in parallel for multiple transport means which are located at different positions.

5. Conclusions

In this article it is pointed to the necessity of an active monitoring system for the transport of dangerous goods. Process monitoring in real time, the aspect of security is raised to a higher level, having direct access to the parameters of the vehicle and the condition of transport. The concept of monitoring of hazardous substances, with the aim of increasing security as a result of manipulative activity is particularly important in the system of transfer stations and intermodal transport, in terms of further researches in this field.

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