REAL TIME TRACKING CONVEYANCES AND BIDIRECTIONAL DATA COMMUNICATION

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INTRODUCTION

Due to substantial progress in (micro)electronics and the fast growing calculating capabilities of small computing systems real time remote vehicle tracking even with high precision became available for a lot of potential users.

At this moment a lot of different equipment became available on the market based upon different techniques so that it is actually complex to make a choice. Depending on specific requirements (maximum time delay - confidentiality - ...), needs (coverage of one country - more countries - ...) and other limitations (a few vehicles at a moment or more than one hundred vehicles simultaneously to be tracked) there can be different solutions to cover a case.

Basically a system will consist of three main constituents :
- a system to locate the vehicle (positioning);
- a system to transmit this information to the tracking station;
- a system to visualise this information.

In its most simplified form a tracking system could consist in a driver transmitting his position on a regular time schedule by radio or mobilophone. In order to enhance confidentiality, and in the case of a predetermined routing, fixed points can be coded and this code transmitted by mobilophone or HF radio transmitter to the tracking station at the moment that each point is reached. Although such a system could still work, nowadays easier and more performant systems should be preferred.

POSITIONING OF THE VEHICLE

Basically two different positioning systems are available : satellite based systems and land based systems.

Satellite based system

Satellite based systems will deliver an absolute positioning (all over the world in some cases) comparable with the positioning calculated upon the relative position of sun, stars, moon etc.

like done in earlier time. The precision of a position is very much function of the precise knowledge of the absolute time and the exact information of the constellation of the satellites like it was earlier dependent of the precision of time-keeping and information of the constellation of stars, moon and sun. (The actual precision is now orders of magnitude better.)

Examples of the satellite based positioning systems are GPS - GLONASS and EUTELTRACS systems.
The global positioning system (GPS) is a satellite based navigation system operated and maintained by the US Department of Defence. The GPS consists of a constellation of 24 satellites providing world-wide, 24 hours, three dimensional (3-D) coverage. Although originally conceived for military needs, GPS has a broad array of civilian applications including surveying, marine, land, aviation and vehicle navigation. The intrinsic accuracy of GPS is very high (~ 1 m) depending on atmospheric conditions and integration time.

Due to an intentional injected random error in the signal that is available for civilian use (selective availability - S.A.) an error of ~ 100 m in longitude and latitude and ~ 200 m in altitude is normal. This source of error can locally be avoided by the use of differential GPS and so reduced to a few meters within the range of the VHF transmitter (~ 150 km).

Glonass is a similar Russian system, not so frequently used for civilian purposes in western Europe.

GPS and Glonass are passive systems. Localisation is done in a receiver with a build-in microcomputer. This system can also give very precise time information together with speed direction e.a. information.

Another completely different satellite based system is EUTELTRACS.
This system which is based upon two geostationary satellites covers whole Europe, the Middle East and Northern Africa. The positioning has an accuracy of about 100 m and the system incorporates a communication system. The system is more or less standardised for fleet management.

Earth based systems

Earth based systems will give a position relative to fixed points that are used for positioning (transmitter antennas).
These systems are based upon the reception of radio signals (VLF band) and are regionally limited.

Earth based systems like e.g. Datatrak are systems that are based upon a number of fixed (VLF) transmitters that are located around or over the area of interest. The positioning is made by the receiver relative to the antennas. If the region of interest is well covered by the signals and is limited in area (such as Belgium e.g.) an accuracy of ~ 20-30 m is achievable.

Systems of this type are in use in the UK, Argentine, South Africa, the Netherlands and Belgium.

DATA TRANSMISSION

Once the vehicle has fixed its position, this information has to be transmitted to the tracking centre; some systems have a build-in data transmitting system (Euteltracs, Datatrak), other systems leave it up to the user to decide which way is used to transmit the information and under what form. Some typical cases are given below.

Euteltracs

Euteltracs is an integrated system that incorporates location and data transmission in one system. Data transmission is two ways - it means that information can be sent to and from the vehicle. The communication between the vehicle and the ground station goes over the Eutelsat satellites. The communication from the ground station to the user is co-ordinated by a provider. The individual user has no control over the protection of the information. The positioning information can not be coded or encrypted by the user.

GPS Inmarsat

As the positioning is purely passive, the user has to add the communicating system. There is a very broad spectrum of communication systems available depending on the requirements of covered area and number of vehicles.

If communication over very large areas is necessary, a good choice could be satellite communication. In this case it is possible to use e.g. combined systems such as GPS-Inmarsat C Trimble combination. The user has the possibility to use one of the standard protocols (land, sea mobile) or to use a personalised protocol which gives the opportunity to encode and/or encrypt the transmitted information for security (confidentiality) reasons. Depending upon the frequency of position reports that are required and the amount of information to be transmitted one can use the standard Inmarsat mode (with handshaking) or the data reporting mode.
For on-line remote vehicle tracking the last mode has the advantage that, depending upon the protocol, the time delay between the fixing of a position and the receiving of the information at the tracking station is 40-80 sec. In this mode, the information is transmitted from the vehicle to an Inmarsat satellite, from that satellite to a ground station and from there by X25 or ISDN lines to the tracking station (user). At this moment data-reporting between two mobile stations is not commercially available. For higher security it is possible to communicate from the tracking station via Inmarsat satellite - ground station - Inmarsat satellite - to the vehicle and back, without the use of fixed lines. Typical delay for each message is about 2-4 minutes.

GPS - GSM or Trunking

In regions where good GSM or Trunking coverage exists, it is possible to use these communication systems to transmit the position information, if necessary in coded or encrypted form. The reliability of the system depends merely on the communication system. Some GSM providers give the opportunity to use SMS transmission for this use. As this form of data transmission is less sensitive to saturation it enhances the reliability of the system. One of the limits for the use of GMS is the limited coverage in some areas.

Datatrak

The Datatrak system, which is based upon a "Loran like" VLF radio-locator positioning system has a very specific incorporated communication system. The information (position and others) that is collected in the vehicle is transmitted to a central station of the provider by a two way VHF communication network using a system of time sharing. From this central station the information is distributed to the different users over telephone lines (leased lines) or via teletext depending on the amount of information to be transmitted (the number of vehicles to be followed etc).

VISUALISATION OF THE INFORMATION

In order to take advantage of the high accuracy of the modern positioning systems the use of appropriate maps is mandatory. It is obvious that, for the continuous tracking of more vehicles the use of electronic (computer) maps is to be preferred.

It is very important that the map corresponds with the positioning system. In the case of GPS the datum of the used map and the co-ordinate system should correspond with the GPS settings. High precision, high definition maps need a lot of computer memory.

Pixel based maps are very pleasant to look at, but in the case of high definition needs very large files (several hundreds of megabytes to display Belgium on street level).

Vector based maps have the advantage to be easy scaleable on the screen, need files that are not so large (~ 80 Mbytes Belgium streets), but look not so nice in general and care should be taken to verify that the map is sufficiently precise for the use needed.

It is worthless to use a very precise positioning system (e.g. differential GPS) where it is superposed on a non adapted map or when the datum of the map does not correspond with the datum setting of the GPS system. Taken into account the fact that the default datum for GPS is the WGS84, also maps in this datum should be preferred if available. This can be very different from one country to another. What concerns the Belgian territory, maps distributed by Vierbergen under the name Cruise-A-Way are a good compromise taking into account detail - precision and memory needs (85MB).

The maps (electronically and printed) issued by the National Geographic Institute (Belgium) are very precise (~ 1 m) but are relatively expensive and use very big data files. They are based on the European 1950 Datum.

Very largely distributed digital maps of the type Autoroute Express covering the whole of Europe or the separate countries are relatively cheap, require relatively less memory but are not so precise when you leave motorways (errors of several hundreds of meters are common).

A very pleasant map is the combination, issued by De Rouck in Belgium, of a general (vector) map for Belgium, main roads and a very detailed (scanned) map on street level. Other European countries will be issued in the near future.

DESCRIPTION OF AN EXISTING SYSTEM

Some years ago, TNB decided to implement a satellite based on real time tracking system in order to replace the existing HF-link based system. The system has been developed together with SONAL to meet with our very specific needs and requirements :

- simultaneously tracking of up to 8 vehicles;
- totally automatic, without intervention of driver or co-driver;
- useful over the territory of Belgium extendible to the whole of Europe;
- very high level of confidentiality;
- high level of fiability;
- update of position < 3 min.;
- precision < 200 m;
- the system has to be easily built and used in trucks and escort cars (shock resistant / 12-24 V).

Hardware (mobile)

As positioning system we decided to use GPS because the other easy available systems (Eutelsat - Loran like systems like Datatrak) did not allow us to encrypt the messages or to choose the communication system.

For communication, we chose for Inmarsat C, land mode taken into account reliability and coverage (GSM did not cover the sensible areas in Belgium at that time).

The Galaxy 400 of Trimble was the best suited combination for our use but we decided to develop a customised message format instead of the existing protocols. For this a microcomputer with dedicated simple terminal was taken.

Hardware (fixed)

The tracking station consists in 3 PC's that are coupled together in a small network.
We receive the messages by an X25 line through a modem. The information as such is than decrypted in a first PC and stored on the hard disk. From there it is in parallel taken over by a PC that will manage the database of information (storing, sorting, display by vehicle,...) and by another PC that will display the position on an electronic map.

Software

The software we use is developed specifically for our needs by Sonal in order to achieve an optimised system :

- from the GPS the time, position, speed and direction information is extracted; some specific information of the vehicle is added (status bits e.a.) and this set of information is sent to the tracking station. In "routine mode" the link is made in data reporting via the ground station of Burum and than further by X25 dataline. By combining and optimising the data format we reduced the number of bits in such a way that we need only one packet per report. Every 3 min. a data report is sent from each vehicle to the tracking station. The delay is about 40 sec. In "safe mode" the link is made in double hub mode using standard Inmarsat hand-shaking

protocol. This mode is slower (~ 3-4 min. delay) but safer due to the fact that the content of each message is verified. In this mode the information is received at the tracking station by an Inmarsat terminal, no use of data lines is necessary.

- the position is displayed on a computer using Auto-Route Plus. This software has been taken at that time due to the high speed of updating the chart taken into account the drawback of errors in small roads and the lack of detailed information.

The complete set of information of each trip is stored on two of the PC's and regularly backed up on a Magnetic-optical device.
The whole system is powered by battery powered system which allows an autonomy of ~ 2 hours in case of complete absence of main power.

OPTIMISATION FOR THE FUTURE

- The existing system will be updated :
  - with better maps for more precise location;
  - to a Windows 95 or Windows NT system allowing the simultaneous tracking up to 256 vehicles using different protocols and codes.

- In order to enhance the reliability further, the use of a complete independent communication channel is under investigation (GSM ?).

- Taken into account the fact that in the future S.A. will probably be switched off by the US - D.O.D. and because the precision we obtained with the actual GPS is sufficient the use of differential GPS is not envisaged. Some GPS systems, like the Trimble - Lassen 8, are surprisingly precise.

Actually tests are running together with SONAL with systems using this (very compact) GPS coupled with GSM-SMS. This system is very promising for the future.