Global Positioning Monitoring System for Electric Vehicle Fleets (GPMS)

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Abstract

A purposely developed global positioning and monitoring system, having the capability to store time series of location coordinates and performance parameters of identifiable electric vehicles was realized. The information may be used off-line for vehicle performance evaluation as well as fleet management. For that purpose, the data collected is interfaced with a Geographic Information software to produce the itinerary of each vehicle. The vehicles may be tracked on-line if an appropriate radio or cellular phone link is included in the system.

OBJECTIVES

The purpose of this work was to realize an EV monitoring system for the management of electric vehicle fleets and performance evaluation.
To realize a simplified onboard installation of the monitoring system.
To verify the applicability of GPS data for fleet operators.
To realize an EV fleet monitoring system with enhanced capabilities.

The Global Positioning Monitoring System (GPMS) provides the capability to fleet operators, with the help of GIS, to compare the route traveled by the vehicles with the energy consumption, distance traveled and time required for the trip. This way alternative routes may be chosen for lower energy consumption and/or reduced trip time etc. The system installed in the vehicle, with the addition of a radio or cellular link, may offer also the possibility to transmit its location in predetermined time intervals or with the push of a button, to send a message for help, in incidences such as an accident, vehicle malfunction etc. In these cases, the vehicle control center receives the location of the vehicle with an accuracy of several meters.
Such systems improve the confidence that drivers have towards their vehicles, and also help in the management and logistics of vehicle fleets.

Hardware

The GPMS is a development, based on the Simplified Monitoring System (SMS) [1], that was realized within the framework of the JOULE II project : "Programme for the Collaboration between CEU and National Programmes on Electric Vehicles in Europe". It retains all the features of the SMS in terms of fleet management and electric parameters collection, but it is enhanced with the integration of a GPS credit card receiver unit, with an active antenna, both made by Motorola. The GPS may track up to 8 satellites simultaneously and possesses a timing accuracy of ±500 ns with selective availability. One of the important features of the the GT Oncore GPS receiver is the capability to provide the new coordinates in less than 45 seconds from power up. The reacquisition time after satellite signal obscuration, of more than a minute, is less than 3.6 seconds. The last features are important for vehicle applications, when the vehicle is first powered up and also in city street driving, where there is reduced sky visibility. The GPS receiver supports differential correction (DGPS) for applications that require 1 to 5 meter accuracy. The sampling rate of the GPS data is selectable between one and 255 seconds. In mobile application, during acceleration, there is an apparent frequency shift in the received signal due to Doppler shift. In order to track the signals through acceleration, the tracking loops are wider in order to accommodate the maximum expected vehicle acceleration and velocity (up to 4.5 meters error in location for every G of acceleration).

The GPMS is supported with a user friendly, menu driven Windows software, for communication through RS232 between a PC and the GPMS datalogger. The software provides the possibilities to program the data collection session according to the fleet operator's needs, and to store data files from the GPMS to the PC etc. The output data files are in ASCII format for easy processing with commercial spreadsheets.
The prototype GPMS datalogger developed by CRES, is based on the Motorola microcontroller MC68HC11F1. The maximum of its resources are : 8 analog inputs, 8 digital inputs, 8 digital outputs and 3 PWM inputs/outputs. The software-controlled power-saving modes make the MC68HC11 family especially attractive for automotive and battery-driven applications.

MEASURED PARAMETERS

A reduced number of parameters is being monitored which usually satisfies the data needs of various fleet operators, decision makers and industry. The sampling rate may be of one second or more for position coordinates, altitude, temperature, and in the millisecond range for the electric parameters. The following parameters (see Table I) seem to be a minimum basic set, that can be potentially increased or modified, according to specific requirements [2].

Table I : GPMS monitored and derived parameters

	Parameters	**Description**	**Determined by**
1	Absolute Time	Day, Month, Year, Time	GPS and onboard real time clock
2	Position of the Vehicle	Coordinates in degrees	GPS
3	Location altitude	in meters	GPS
4	Vehicle Speed	speed in km/hr	GPS
5	Distance	derived from speed	GPS
6	Accel./deceleration	in m/sec^2 (derived from speed)	GPS
7	Current of driving battery bank (negative and positive)	- Driving cycle - Charging cycle	Split core Hall effect transducer
8	Voltage of driving battery bank	- Driving cycle - Charging cycle	Hall effect transducer
9	Ambient Temperature		Digital thermometer
10	Battery bank Temperature		Digital thermometer

The GPS registered parameters are accurate within several meters (usually between 50 and 100 meters) for position and altitude. In the validation section, details are given for test runs with the GPMS and the evaluation of the collected data, by comparison to a second data acquisition system. The operating temperature range of the GPMS extends from -20 to +70°C. The degree of accuracy of the electric parameters ranges from 1% to 2%, and for calculated ones, it is usually less than 3% [2]. The temperature is being measured by a digital thermometer with an accuracy of ±0.5°C.

INSTALLATION

The installation procedure of the monitoring system and sensors are simple and non-intrusive. They do not intervene with the electric power circuits of the vehicle. The monitoring system does not require the installation of a sometimes awkward speed sensor, that has to be custom fitted to the various automobiles used in a fleet. One of our goals, is to prove with this work, that speed and acceleration data can be obtained with the help of the integrated GPS receiver, instead of a speed sensor. The installation simplicity of the sensors/transducers, in the shortest possible time, by trained technicians, is very important for easy retrofit in vehicle fleets.

VALIDATION

The GPMS was installed in the Fiat Panda Elettra owned by CRES, in parallel with the SMS and the Campbell CR-10 data acquisition system, that is permanently installed on the vehicle. Concerning the electrical parameters and the temperature measured, the GPMS performed exactly as the SMS [2], as expected, since it is identical to it. The validation that follows, will only take into consideration the GPS speed, the derived acceleration and the new introduced parameters : coordinates (vehicle location), vehicle location altitude.

The first tests at CRES have shown that the GPMS operation is satisfactory. In figure 1, a time window of the speed data is presented, taken with a 4 blade speed sensor, that produces four pulses per revolution of the speedometer cable of the vehicle (by electro-optic coupling), which in turn corresponds to 1.75 revolutions of the vehicle driving wheels.

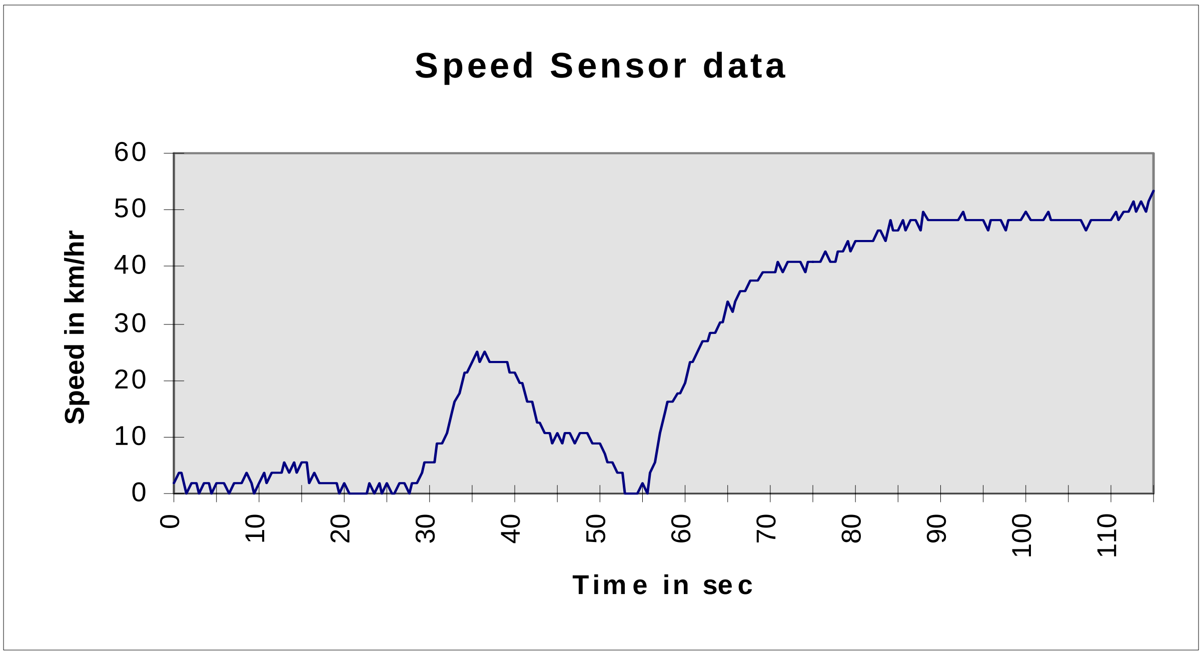

Fig. 1 : Speed data collected with the 4 blade optical sensor.

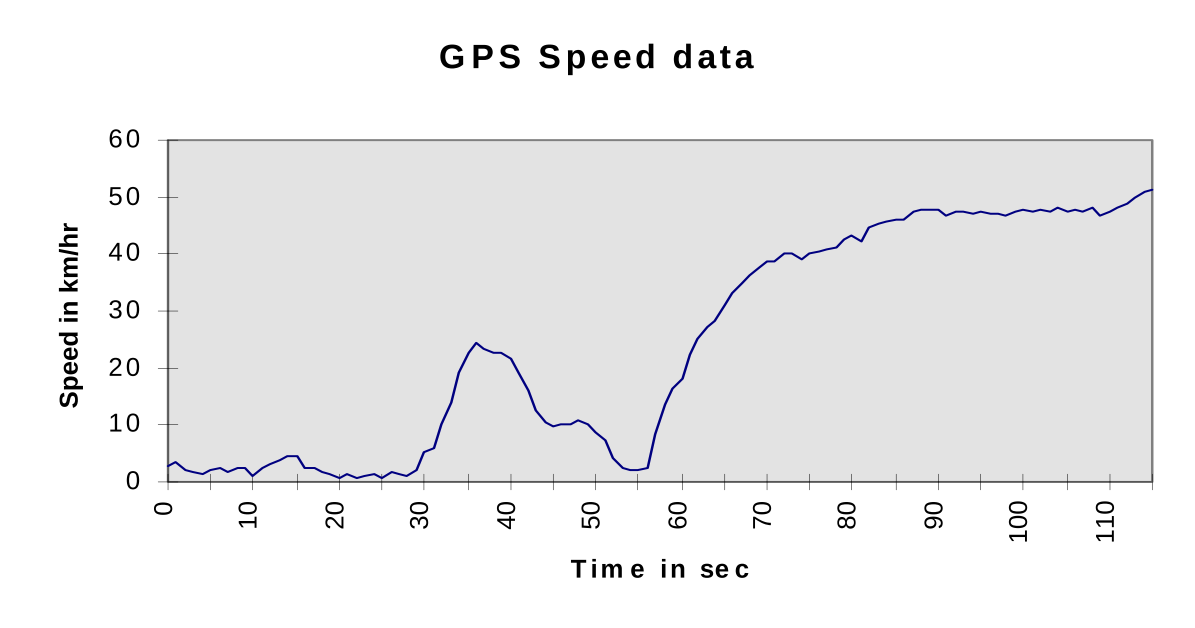

Fig. 2 : Data collected with the GPS receiver.

In figure 2, the data taken with the GPS receiver during the same test is presented. It is noticed that the GPS follows the vehicle speed very closely. Discrepancy is evidenced in very low speeds, under 2 km/hr, where the GPS never gives a zero velocity, even if the vehicle is stopped. In the car industry, an accuracy in the vehicle speed better than 5 % is considered to be satisfactory. For this reason, it is considered that the vehicle speed is satisfactorily tracked by the GPS receiver. Overall, it is determined that the vehicle speed accuracy is approximately 2 Km/hr RMS. Concerning the distance traveled by the vehicle, it is derived from the GPS speed raw data every second. The accuracy here is the same as that of the speed data, because the error introduced by the time interval between the data samples is negligible.
Figure 3 presents the calculated acceleration/deceleration values from GPS speed data, for the same time window as in figures 1 and 2. The point here was to show also the effect of the speed fluctuation, when the vehicle is not moving. A few dispersed events were noticed, where unusually high acceleration is calculated with no other reason.

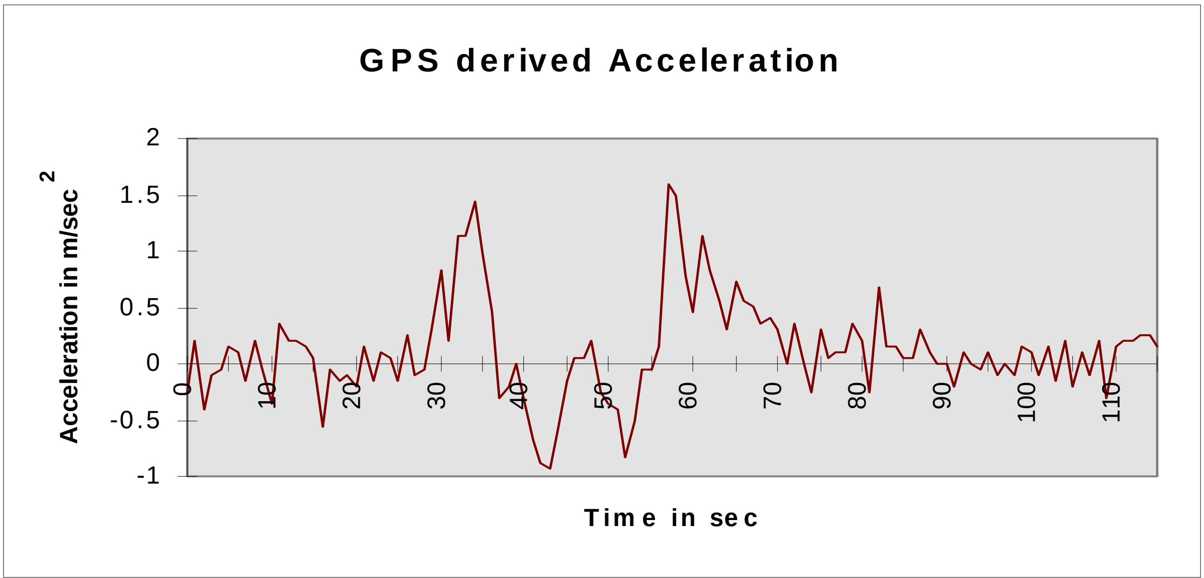

Fig. 3 : Acceleration values derived from GPS speed data.

As for the altitude data registered by the GPS, they provide an idea of the geographic contour of the itinerary, but the accuracy in absolute values is in the order of 200 meters. The GPS indicated the highest altitude of a trip being 480 meters, where in fact it was 260 meters. This discrepancy is also due to the selected centre of the GRS 80 ellipsoid being used with the WGS-84 projection, which is not optimized for Greece. The longitude and latitude values will be discussed in the next paragraph, together with the vehicle route geographic visualization software (Mapinfo and Geographic Tracker).

GIS Interface

The vehicle location coordinates collected during the trip, are stored in the GPMS memory. At the end of the trip or monitoring session, a file of ASCII format is prepared. In case of possible on-line monitoring of the vehicles, a special format file, NMEA 0183, is automatically provided by the Motorola GPS receiver. Both the ASCII and NMEA 0183 formats are interfaced off-line or on-line to the GIS software, by Mapinfo and Blue Marble Geographics for visualization of the vehicles on a map.
The under-laying map used in figure 4, is a window view of a larger map of scale 1:50.000, from the Hellenic Military Geographical Service. The map was geo-referenced on the WGS-84 projection system in order to accept the GPS coordinates. The consecutive white circles in figure 4, represent the location of the electric vehicle, taken every second. In the right half of figure 4, notice the deviation from the main road that was followed and the sudden bend (point A), that denotes the intentional variation in error introduced by the US department of defense satellites (called selective availability). The white arrow in the same figure indicate the direction of vehicle movement. Point B, indicates the end of data collection for that specific route.

Fig. 4 : Visualization of vehicle trajectory on a map, using GIS.

The map in figure 4 does not provide details of city streets, for that matter, scanned copies of a guide-map were used. Each scanned guide-map page was geo-referenced by Mapinfo, as a WGS-84 projection. The coordinates of at least 4 points should be used for geo-referencing, but usually the use of more points is encouraged to avoid blunders. The maps are then opened as layers of the already geo-referenced World map (available by Mapinfo) or maps from the Hellenic Military Geographical Service, to provide a reference with respect to the geographical environment. Finally, the program Geotrack is run and the collected data are viewed on the PC screen, representing the time series of the vehicle location. When a large geographical area is viewed on a large scale map, the guide-map pages may be initially invisible. When the operator zooms into the map, then the guide-map pages become apparent, as seen in figure 5, providing street level resolution.

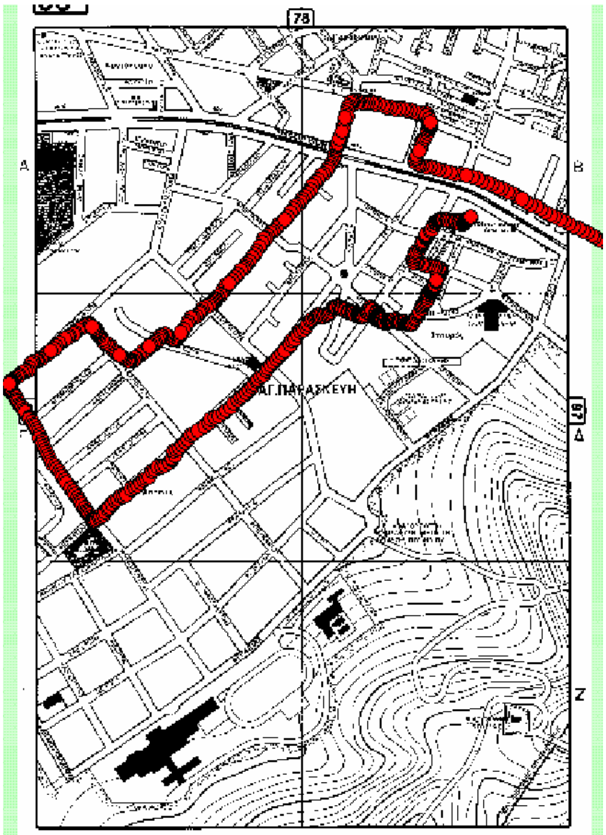

Fig. 5 :Street level details of the under laying guide-map.

Once the geo-referenced maps were available, we had the opportunity, with the help of a laptop computer, to drive and watch in real time the vehicle's location on the PC screen.

Conclusion

A purposely developed, global positioning and monitoring system was realized, having the capability to store time series of location coordinates and performance parameters of identifiable electric vehicles. The information may be used off-line for vehicle performance evaluation, as well as fleet management. For that purpose, the data collected were interfaced with a Geographic Information software to produce the route of each vehicle. The vehicles may be tracked on-line if an appropriate radio or cellular phone link is included in the system. Depending on the application and other requirements, the extra cost of differential GPS may be avoided. Applications that are viable with non-differential GPS are those were the transport route is one track (trains, buses/trucks), or the size of the vessel and its speed make render higher accuracy unnecessary (ships, airplanes). Another possible application is the location of lost vehicles and vessels.

References

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