The Cost of Development of a New System to Control Drivers using GPS location and Identification through the electronic ID card

J.A. Gutiérrez-de-Mesa, L. de-Marcos, J.J. Martínez, J.M. Gutiérrez, J.R. Hilera, S. Otón, S. and R. Barchino
Computer Science Department, University of Alcalá, Alcalá de Henares, Madrid, Spain

Abstract - *This paper presents new methodologies in the analysis of the driving and rest times demanded by the Spanish Ministry of Public Works to all transport vehicle drivers through a control system using GPS location and identification through the electronic ID card. It is proposed the creation of a control system for the vehicle driver through GPS technology. Furthermore, technologies will be used for the data transport between the device that will be included in the vehicle and a server containing the characteristics of each route traveled by different drivers. The proposed control system will use as access control the electronic ID card in order to avoid any sort of vulnerabilities related to phishing (identity thefts). It aims to study the technology used by the electronic ID card. So, the main technological innovation is the use of the newborn electronic ID card alongside with the most advanced wireless technologies in the field, integrating both concepts in the same electronic device.*

Keywords: Cost driven software, DNI-e (e-IDs), GPS, wireless technologies, Wi-Fi, bluetooth, transport.

1 Introduction

The recent introduction of the electronic ID card in Spain allows a new kind of interaction between people and electronic media, faster and easier than the traditional one. This kind of interaction is similar to that used with credit cards, in which users introduce the card into a reader, type their personal identification number (PIN), and if all data are right they can begin to operate.

Thus, one of the main aims of the electronic ID card is that users interact in this way, but without limiting the area of tasks to a single field.

Security is one of the most interesting fields. In this field they can be developed systems that taking into account the universal the universal nature of the electronic ID card avoid the need to generate a means of identification (ie card) for each system.

Control systems of transport vehicle drivers nowadays are the classic analog tachograph, which displays the driving and rest times by means of an approved paper disc. The ministry is demanding a new device; the digital tachograph which looks like a car radio. It is used a digital card for the identification of the driver.

This project proposes the creation of a control system of the vehicle driver through a GPS technology. This technology aims to:

- Locate the transport vehicle to track the trajectory. As a result of this tracking the following parameters will be obtained:
  - oMeasurement of the average speed and instant speed, controlling at every time the speeding.
  - oMeasurement of the distance traveled by a transport vehicle.
  - oControl of driving times by detecting the vehicle movements.
  - oControl of the driving times by not detecting the vehicle movements.

Moreover, technologies will be used for the data transport between the device included in the vehicle and a server containing all the characteristics of each route followed by each driver. These technologies are:

- Wi-Fi [1]: it will be used in order to transmit all the measured parameters during the route to a server that will calculate the possible infractions.
- GPRS [2]: it will be used in order to transmit all the measured parameters during the route to a server that will calculate the possible infractions, if the driver does not have Wi-Fi connection at the end of the route.
- Bluetooth [3]: it will be used in order to transmit all the measured parameters during the route to a device located in a short distance.

The proposed control system will use as access control the electronic ID card in order to avoid any sort of vulnerabilities related to phishing (identity thefts). It aims to study the technology used by the electronic ID card.

With the appearance of the new electronic ID card there are new possibilities related to the access control and control systems of transport vehicle drivers. The attempt of manipulating the current control systems causes the search for

new less vulnerable systems; therefore the aim is to identify the transport vehicle driver through the electronic ID card, allowing a practical and safe identification.
The electronic ID card also allows to unify all identification systems into a single system. This idea is trying to be developed in order to make it possible the identification in all European Union countries customs by means of the ID card, replacing the passport.
The control systems of transport vehicle drivers are limited at the moment. As an example, until a few months ago the famous analog tachograph was still used. It allowed an easy manipulation by the drivers, issue that attempts to be remedied by using the electronic ID card.
However, since January 2008 the Spanish Ministry of Public Works has imposed the new digital tachograph, which detects possible manipulations of the performed measurements. Therefore, it requires a digital identification card specific for the tachograph to operate.
This project will provide the possibility of identifying the transport vehicle driver by means of a common document as it will be the electronic ID card. It will avoid any sort of manipulations, since the measurements of the required parameters to control the driving and rest times of the driver will be carried out by GPS location.
The system is composed of:

- **A control center**, with database management and connectivity to the tachograph placed in each vehicle.
- **Collection of devices** required to perform the measurements of each vehicle and communicate with the rest of the system, comprising:
  - o**Tachometer**: device to measure the shaft turn speed, usually the engine turn speed in revolutions per minute (RPM).
  - o**Electronic ID card reader**: reader device or the e-ID, which allows the driver to be authenticated and then the whole system will start to operate.
  - o**Tachograph:** electronic device that records several events generated by a vehicle during its driving. The recorded events usually are: speed (average and maximum), RPM, mileage, sudden braking and accelerations, idle time (the vehicle is stopped with the engine running), among others. These data can be collected by a computer and stored in a database or printed as graphs for further analysis.
- **Multimedia mobile device** for the traffic policeman, easy-to-use, intuitive and with connection to the corresponding vehicle through Bluetooth technology.

2 Main Aims

The main aim of this project is to find new methodologies to analyse the driving and rest times demanded by the Spanish Ministry of Public Works, for all transport vehicle drivers through a control system using GPS location and identification by the electronic ID card. The system will select the most suitable transmission technology for each case automatically, ie, not user intervention is required. Among the used technologies there have been included GPS, GPRS, WIFI, BLUETOOTH and ZIGBEE4. The idea is to switch automatically from one technology to another depending on factors such as coverage, cost or transmission speed.
As a specific aim it is the development of the information system required to carry out the tracking, control and analysis tasks of the different routes traveled by each one of the drivers. They will be developed specifically:

- **Tracking system and data collection.**
  - oBased on GPS for the location and wireless technologies (GPRS / UMTS / WiFi / ZigBee and Bluetooth) for the communication.
  - oData storage in the database.
- **Data obtaining system by the agent.**
  - oQuantitative data analysis according to repports obtained from the information stored in the tachograph.

Thus, the different scenarios that may occur and the different possibilities they show are exhibit in the following images:

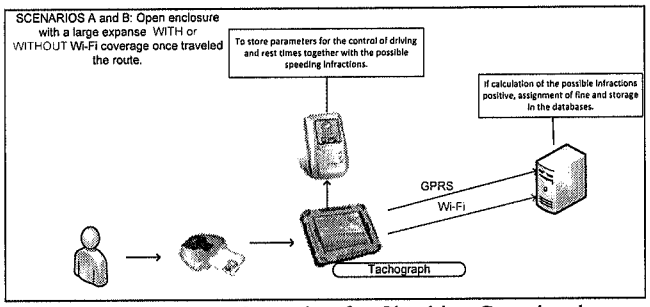

Fig 1. SISCOVET Operation for Checking Completed Routes

The following picture shows a scenario situated in an open enclosure with the possibility of transmitting data through Bluetooth, in which it is expected to check infractions of previous routes:

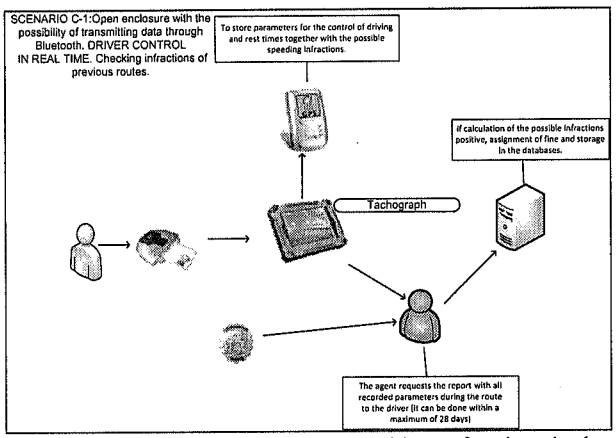

Fig 2. SISCOVET Operation for Checking Infractions in the Previous Routes

The following picture shows a scenario situated in an open enclosure with the possibility of transmitting data through Bluetooth, in which it is expected to check infractions of the current route:

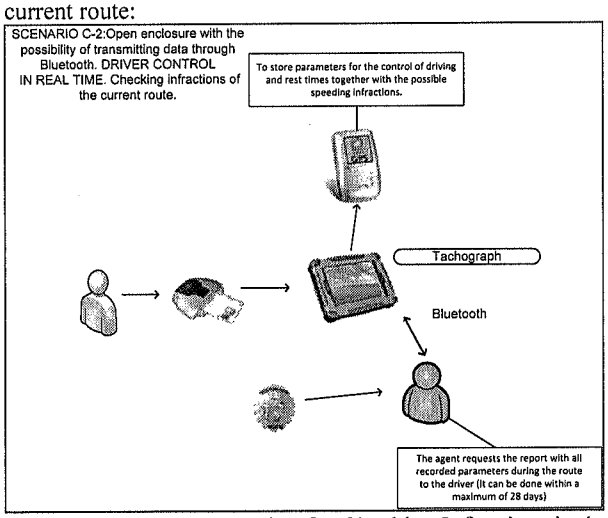

Fig 3. SISCOVET Operation for Checking Infractions in the Current Route

The system will comprise the following elements:

Tachograph device: used by the driver to communicate with the server and send collected data of the route. It will be able to communicate with the mobile device and the server. Through a user interface the following possibilities will be offered:

- Generation of reports from different periods of activity.
- Transmission of the stored information to the server.
- Connection by Bluetooth with the mobile device and transmission of the report requested by the agent.

The storage capacity of the tachograph will be up to 28 days of information and the generated reports will be able to contain the information of those 28 days. When sending the information to the server it will be used any of the possible technologies.

Mobile device: through which the search of the driver infractions will be provided to the traffic policeman. By activating the Bluetooth device, the license plate number will be sent, the infractions will be obtained and a report will be displayed in the screen.

Server: where the data from the tachograph are stored and processed. It comprises an object-relational database management system PostgreSQL which will manage the data sent by the tachograph.

The SISCOVET "Control system of Transport Vehicle Drivers using GPS location and Identification through the electronic ID card" system must fulfil three basic functions:

- **To locate the driver and store information** sent by him about the route being traveled.
- **To allow the collection of these recorded data by the agent.** If a traffic policeman stops a transport vehicle, once the required identification is done, he/she will be able to obtain reports and data stored in that moment in the tachograph of the vehicle. This way, he/she will carry out as many investigations, warnings... as needed.

It is important to think of them separately, since the requirements of each one of these systems are quite different. The location system must have the same reliability than the telecommunications network, and be compatible with the telecommunications standards and network equipments from different manufacturers.

3 Description of the project

Here is described the SISCOVET system specifying its scope, technological environment and main users.

3.1. Determining the scope of the system

This project stems from the advisability of developing a specialized computer system that allows centralizing data from a GPS, a digital tachograph, and the electronic ID card, to perform a better tracking of a transport vehicle.

The system comprises:

- A control center, with database management and connectivity to the rest of devices.
- Mobile device with Bluetooth connectivity for the traffic policemen.
- A GPS device to obtain the location.
- A digital tachometer, integrated in the vehicle.
- An electronic ID reader.
- Web server and database.

This system is conceived to improve the present tachometer system. So, thanks to a GPS device it will be possible to know the route traveled by a vehicle or the exact point where it is. The same applies to the electronic ID card; it will provide more data than the provided by the present driver card.

Likewise, the system controls more exhaustively that the vehicle driver complies the traffic regulations established for the sector.

The main characteristics of the system are:

- Establishment of a system to detect the vehicle location using GPS technologies in order to create a route of travel.
- Establishment of a connection with mobile devices that request information about the stored routes in the device, through Bluetooth.
- Data storage in the device for further verification by a traffic policeman.
- Sending of data to a server to store them and subsequent consults.
- From the digital tachograph, reading the driver data and extraction of speeds and rest times.

The equipment can use different wireless communication technologies; it will choose one over another depending on the coverage of each place relating to the cost it entails:

- Preference of using WiFi in regards to GPRS because of the cost of the telephone operators, and the data transmission speed.
- Bluetooth connection in connections with mobile devices used to control infractions.

It has been adopted an object-oriented approach (O.O), in order to make the most of its advantages:

1. Greater structuration when programming.
2. Compaction of data (Encapsulation).
3. Easy to reuse code (Easy maintenance and expansion)
4. Better presentation of the problem.

3.2. Identification of the technological environment

In the following subsections it is carried out a high-level definition of the technological environment required to meet the needs of information, specifying the possible constraints and restrictions. To do so the technological environment has been taken into account.

3.2.1 Area of action

The area of action will be focused on all Spanish geography, specifically in those vehicles devoted to transport.

3.2.2 Control center

The control center is the server to which all data from the tachographs will be sent.

This control center will have a database that will store all information sent from the tachographs. Also it will have a program capable of calculating infractions and generating reports with them.

Furthermore the control center will have a web server that, through a page, will offer information about the stored data.

3.2.3 Multimedia mobile devices

The application developed for these devices uses a programming language that allows the execution in embedded devices, such as PDAs or Tablet PCs. It offers a Bluetooth connectivity, but also taking into account Wi-Fi and GPRS connectivity.

This application will be used by traffic policemen; they will establish through it a Bluetooth connection with the vehicle tachograph to obtain the route reports.

This application will be able to ask for reports to the tachograph, both in the current route and in previous ones. The application will receive this reports (in XML format) to show it in the screen for the traffic policeman's requirements.

3.2.4 Point Capture Device

Module to make GPS positions regularly at a predetermined set interval of time, to store in the tachograph the coordinates the vehicle has traveled.

The mobile point capture device will be activated once the tachograph is activated, sending at that moment the current location; and it won't be deactivated until the tachograph is switched off, sending then the current location again.

Thus, it is possible to control the whole route of a vehicle, no matter whether it is in motion or stopped.

3.2.5 Personal Data Reader Device

This device will be the electronic ID card reader.

Once the system is started, the tachograph will ask the ID card to be introduced in the reader device in order to register the driver. If no electronic ID card is introduced in the reader, the tachograph will emit a warning failure.

By reading the electronic ID cart it is possible to authenticate that the driver is really driving the vehicle.

The system stores the ID number, surnames and name of the person.

The law establishes that the ID card cannot be compulsorily trapped in any device or place. So the ID card is not required to be introduced in the reader during the whole route. When starting up it will be indispensable to introduce the ID card in the reader, but it can be removed, if desired, once the system indicates it.

3.2.6 Device for calculating speed and working times

This device corresponds to the current digital tachograph, included by law in all transport vehicles. This device nowadays interacts with the driver in the following ways:

- When starting up the vehicle, it asks for the insertion of the driving card by the driver.

Likewise, this device will control automatically:

- State of the vehicle (stopped or in motion) to establish the worker's state.
  - If the vehicle is stopped, the device will establish the worker's state "working".
  - If the vehicle is in motion, the device will establish the worker's state "driving".
- Instantaneous speed. By means of sensors placed on the vehicle the device will instantly know the speed it has. This way it controls if the vehicle exceeds the established limits, emitting a warning in that case.
- Rest times. According to the working time there is a rest time. This device will control that these times are not exceeded, emitting a warning in that case.

These data will be stored (together with the data related to the driver identification) to, among other things, generate reports that may be subsequently requested.

3.3. Identification of participants and end users

Here are identified the participants and end users both in the procurement of requirements and the validation of the different products and final acceptance of the system.
Given the importance the collaboration among users has in the process of obtaining requirements, it is worth determining who is going to participate in the work sessions, specifying the functions and assigning responsibilities.

3.3.1 Driver

This is the user who drives the transport vehicle, that is, the person from which all data is collected during the route; the protagonist of all measurements and operations of the system. So, the tasks of this user are:

- He/she will be responsible for the mobile device during its use.
- He/she will use all user functions of the application.
- He/she will provide his/her personal and registering data in the first use of the application, in order to be registered in the system, through the introduction of the electronic ID card in the reader and the driving card in the digital tachograph.
- He/she will be responsible for the maintenance of the device during its use.
- He/she will interact with the digital tachograph to introduce working and rest times as appropriate. The driving times will be automatically detected by the system. The working, rest or available times have to be introduced by the driver.
- He/she will activate the Bluetooth connection for the device to communicate with an agent's mobile device.
- He/she will take the driving card out, indicating the end of an activity.
- He/she will drive the vehicle travelling the corresponding routes.

3.3.2 Administrator

This is the user in charge of the complete system. The administrator must know how they work each of the applications comprising the final system. Thus, the operations focused on being performed by him/her are:

- Responsible for managing and maintaining the application in the server.
- Responsible for maintaining the accuracy and integrity of the database.
- Responsible for detecting errors of malfunctions of the system and communicate them to the maintenance team.
- He/she will add the different devices that the tachograph deals with, such as the e-ID or GPS reader.
- He/she will add the users of devices, ie the drivers.

3.3.3 Traffic policeman

This is the user who may ask for certain data to the vehicle driver with intent to control its work. The characteristics and operations at his/her scope are:

- Responsible for the road safety.
- In case of inspection of a vehicle he/she will control through his/her mobile device that it has not made any infractions, and carrying out the corresponding sanctions if required.
- He/she will connect the mobile device through Bluetooth to the vehicle device to obtain data.

4 Resources

Tackling a project like this requires a multidisciplinary approach and a wide group of experienced professionals in the different areas this project has (research, development, technology, training and marketing). A joint project was chosen in order to enhance the guarantees of success and reduce risks. This way, each organization can contribute its experience and knowledge to the project in those areas in which they have a greater knowledge and proved ability.

It has been considered necessary the following staff from the Alcalá University for the carrying out of this project. First, it will be required a Project Manager in charge of coordinating all tasks to be developed in the project by the Alcalá University; nine researchers from the University to provide ideas and the most updated knowledge in the field, together with the latest protocols; four pre-doctoral researchers to support the above mentioned researchers, as well as to write articles in order to spread the obtained results. Finally they will be required 14 developers in charge of research support tasks, as well as the development of the system. There are a total of 33 people in the development of the system.
The following table contains the schedule for the project:

Stage	Start date	End date
Research	01/07/08	30/09/08
Analysis	01/10/08	11/11/08
Design	10/11/08	31/12/08
Development	08/01/09	24/09/09
Tuning	25/09/09	19/11/09
System Validation	20/11/09	31/12/09

The following table shows in detail the tasks comprising each one of the previous stages.

Task name	Start date	End date
Research	*01/07/2008*	*30/09/2008*
Bibliographical research	01/07/2008	03/07/2008
Literature review	04/07/2008	08/07/2008
Study on positioning systems	09/07/2008	14/07/2008
Study on shipping rules	01/07/2008	03/07/2008
Study on wireless technologies	04/07/2008	09/07/2008
Study on the OOSS of the devices to be used	09/07/2008	11/07/2008
Study on the electronic ID card	15/07/2008	17/07/2008
Study on the readers compatible with the e-IDs	15/07/2008	17/07/2008
Study on the access to the electronic ID card	18/07/2008	23/07/2008

State of the Art	15/07/ 2008	18/07/ 2008
Requirements identification	18/07/ 2008	23/07/ 2008
Requirements review	30/07/ 2008	31/07/ 2008
Design of the information system model	01/09/ 2008	04/09/ 2008
Definition of the technological architecture	05/09/ 2008	09/09/ 2008
Effort estimation	10/09/ 2008	10/09/ 2008
Planning	11/09/ 2008	15/09/ 2008
Establishment of coordination tasks	11/09/ 2008	12/09/ 2008
Requirements identification	15/09/ 2008	17/09/ 2008
Configuration management plan	18/09/ 2008	19/09/ 2008
Establishment of the monitoring plan	22/09/ 2008	23/09/ 2008
Identification of quality properties	24/09/ 2008	25/09/ 2008
Establishment of the quality assurance plan	26/09/ 2008	30/09/ 2008
End of the research stage	30/09/ 2008	30/09/ 2008
Analysis		
Design of classes	18/11/ 2008	19/11/ 2008
User interface design	20/11/ 2008	25/11/ 2008
Physical data design	26/11/ 2008	28/11/ 2008
Design of the system architecture	01/12/ 2008	09/12/ 2008
Exploration of web services	01/12/ 2008	03/12/ 2008
Study on data storage	01/12/ 2008	03/12/ 2008
Services of the presentation layer	01/12/ 2008	02/12/ 2008
Services of the business logic layer	01/12/ 2008	02/12/ 2008
Services of the data layer	01/12/ 2008	02/12/ 2008
Database Design	03/12/ 2008	09/12/ 2008
Verification and acceptance of the Architecture	10/12/ 2008	10/12/ 2008
Generation of Specifications for Construction	11/12/ 2008	12/12/ 2008
Design of the Initial Data Load	15/12/ 2008	17/12/ 2008
Technical Specification of the Test Plan	15/12/ 2008	19/12/ 2008
Implementation requirements	22/12/ 2008	23/12/ 2008
Selection of Development Tools	24/12/ 2008	24/12/ 2008
Review of the System Architecture	11/12/ 2008	11/12/ 2008
Review of the specification of the Test Plan	22/12/ 2008	23/12/ 2008
Review of the Implementation requirements	24/12/ 2008	24/12/ 2008
Identification and Registration of Designer products	26/12/ 2008	29/12/ 2008
Technical Design Document	26/12/ 2008	31/12/ 2008
Obtaining the Application Architecture	31/12/ 2008	31/12/ 2008
Development	***08/01/ 2009***	***23/09/ 2009***
Preparation of the Development Environment	08/01/ 2009	12/01/ 2009
Subsystems Definition	13/01/ 2009	19/01/ 2009
Package Definition	20/01/ 2009	23/01/ 2009
Services development of the presentation layer	26/01/ 2009	29/01/ 2009
Service Development	30/01/ 2009	05/02/ 2009
Server Application Development	06/02/ 2009	15/07/ 2009
Regulatory module development	06/02/ 2009	12/02/ 2009
Development of the Routes Module	13/02/ 2009	19/03/ 2009
Development of the Infraction Component Module	20/03/ 2009	02/04/ 2009
Development of the Server Communication Module	03/04/ 2009	20/04/ 2009
Development of the Sanctions Calculation Module	21/04/ 2009	05/05/ 2009
Module for Generating the Driver File	06/05/ 2009	19/05/ 2009
Vehicle Tracking Module	20/05/ 2009	02/06/ 2009
Module for Intantaneous Visualization of the Vehicle	03/06/ 2009	30/06/ 2009
Development of the Module containing the rules	01/07/ 2009	07/07/ 2009
Development of the Module for computing driven hours	08/07/ 2009	15/07/ 2009
Implementation of the Data Model	01/07/ 2009	14/07/ 2009
Obtaining a Server prototype	14/07/ 2009	14/07/ 2009
Client Application development	06/02/ 2009	07/07/ 2009
Development of the Routes Module	06/02/ 2009	05/03/ 2009
Development of the GPS location Module	06/03/ 2009	19/03/ 2009
Development of the Module for Measuring the Speed	20/03/ 2009	26/03/ 2009
Development of the Module for Measuring Distances	27/03/ 2009	27/04/ 2009
Development of the Breaks Module	28/04/ 2009	12/05/ 2009
Development of the Alerts Module	13/05/ 2009	09/06/ 2009
Development of the Identification Module	10/06/ 2009	23/06/ 2009
Study on libraries to Access to Certificates	10/06/ 2009	16/06/ 2009
Access to the Data Store	17/06/ 2009	23/06/ 2009
Development of the Client Communication Module	24/06/ 2009	07/07/ 2009
Obtaining a Client prototype	07/07/ 2009	07/07/ 2009
Development of the User Interface	08/07/ 2009	27/07/ 2009
Development of the Driver Identification Interface	08/07/ 2009	13/07/ 2009
Development of the Routes Interface	14/07/2009	27/07/ 2009
Interface of the Current Situation of the Vehicle	14/07/2009	27/07/ 2009
Development of the Interface consulting violations	14/07/2009	17/07/ 2009
Interface for Selecting the kind of route-Client	14/07/2009	17/07/ 2009
Interface for Selecting the Rest times-Client	14/07/2009	17/07/ 2009
Development of the Alerts Interface	14/07/2009	17/07/ 2009
Obtaining a prototype of the Graphic Interface	17/07/ 2009	17/07/ 2009
Implementation of the Unit Tests	20/07/2009	31/07/2009
Implementation of the Integration Tests	01/09/2009	15/09/2009
Specifications Review	16/09/2009	22/09/2009
Review of Code, Interface and Components	16/09/2009	21/09/2009
Tests Review	22/09/2009	24/09/2009
Review of user manuals	22/09/2009	24/09/2009
Identification and Registration of Development Products	22/09/2009	24/09/2009
Product obtaining	24/09/2009	24/09/2009
Adjustment	25/09/2009	19/11/2009
Controlling the developed software subsystems	25/09/2009	01/10/2009
Development of stress tests and benchmarks	02/10/2009	13/10/2009
Implementation of stress tests and benchmarks	14/10/2009	22/10/2009
Correction of errors and deficiencies	23/10/2009	19/11/2009
Obtaining performance proofs	19/11/2009	19/11/2009
System validation	20/11/2009	28/12/2009
Establishment of an Implementation plan	20/11/2009	23/11/2009
System Implementation	24/11/2009	26/11/2009
Implementation Tests	27/11/2009	02/12/2009
Acceptance Tests	03/12/2009	09/12/2009
Review of the Implementation and Acceptance Tests	10/12/2009	11/12/2009
Validation and Approval of the System	14/12/2009	15/12/2009
Identification and Registration of the Global Product	16/12/2009	17/12/2009
File of the Project Management Documentation	18/12/2009	23/12/2009
Registration and File in Project Log	24/12/2009	28/12/2009
Project Monitoring and Control	29/12/2009	31/12/2009
Project end	31/12/2009	31/12/2009

5 Conclusions

Once finished, it is important to value some aspects about the work carried out, such as:

- **Scope**: the project has been developed thinking ~~of~~ on a national scope - Spain. Thus, the scope of an application like this is quite important, due to the data registered by the Ministry of Public Works, reporting about the flow of goods [4]. The information about transport by road with Spanish vehicles has been obtained from the Permanent Survey of Goods Transport by Road, a periodic publication of the Ministry of Public Works. This survey reveals that most of the records correspond to transport operations within the country. The operations carried out between Spain and other countries or out of Spain by Spanish carriers are much limited. Hence the usefulness this project can provide to the territory for which it is developed.
- **Possible improvements**: the developed application is a prototype that can be executed in a computer. Therefore, the main improvement would be the implementation of the complete project, fulfilling the main functionality; being executed inside a vehicle. Still, the developed prototype presents all functionalities required to get an appropriate execution and offer all the characteristics.

- **Acquired knowledge.** The execution of this project has provided some knowledge about technologies not very known so far. Among them, they are:
  - **GPS**: global navigation satellite system (GNSS) which allow GPS devices to determine their current location anywhere in the world. The system is nowadays developed and managed by the United States Department of Defense. It is made up of twenty four satellites (21 operatives and 3 backup) orbiting about 20200 km from the Earth with synchronized routes to cover all Earth's surface.
  - **Server**: a server is a computer that, being part of a network, provides services to other computers called clients. A server is also a process that delivers information or serves to other process.
  - **Sockets**: it denotes an abstract concept by which two programs (probably located in different computers) can inter-process any dataflow, usually in a reliable and organized way.
    A socket is defined by an IP address, a protocol and a port number.
  - **Programming Windows Mobile devices**: Windows mobile is a compact operating system combined with a suite of basic applications for mobile devices based on the Microsoft Win32 API.

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