Animal welfare monitoring and livestock traceability during transport

Adriano Di Pasquale[(1)], Enzo Isocrono[(1)], Luigi Possenti[(1)], Cesare Di Francesco[(1)], Walter Di Donato[(1)], Gianluca Fiore[(2)], Johann Hofherr[(2)], Fabrizio Natale[(2)] & Fausto Bonavitacola[(2)]

Summary

The authors present an experimental project that aims to establish an effective navigation system in accordance with European Council Regulation 1/2005 concerning animal welfare during transport. The prototype created during the project consists of both hardware and software components. An onboard unit is installed at truck level. It collects and transmits real-time information of the animal transport to a remote receiver database. A Web/geographic information system (GIS) application is used to analyse and monitor the information received. The architecture of the hardware and software of the project is presented, focusing on the features of the Web-GIS application.

Keywords

Animal, Geographic information system, GIS, Information, Italy, Transport, Web, Welfare, Web services.

Introduction

In recent years, the scientific community has developed a new approach to animal welfare that is based on the principle that animals are recognised as 'sentient beings' (and therefore they deserve the best possible treatment). However, they are also the first link in the food chain and, therefore, animal welfare must be guaranteed, especially on account of its impact on consumers. This new approach has resulted in moving from a position which was mainly aimed at establishing solid requirements to prevent unnecessary pain to the animals (on the farm, at the abattoir and during transportation) as part of an integrated animal welfare/food safety approach. In addition, the traceability of animals in intra-European Union trade is an essential element in the prevention of the spread of animal diseases and an important issue in securing consumer confidence.

In this context, many forms of technical collaboration in the field of the animal welfare and livestock traceability on long journeys have been launched between the European Union Commission Joint Research Centre (JRC) and the *Istituto Zooprofilattico Sperimentale dell'Abruzzo e del Molise 'G. Caporale'* (IZS A&M). In particular, one of the projects is aimed at establishing an effective navigation system in accordance with Regulation (EC) 1/2005 on the protection of animals during transport, in order to ensure that animal welfare and livestock traceability requirements are fulfilled during the journey (3). By recording and transmitting a number of predefined data in real time, the system can ensure compliance with legal requirements for animal welfare and livestock traceability. It should not only contribute to a substantial decrease of the administrative burden for stakeholders and competent authorities but should also assist in

(1) Istituto Zooprofilattico Sperimentale dell'Abruzzo e del Molise 'G. Caporale', Via Campo Boario, 64100 Teramo, Italy
a.dipasquale@izs.it@izs.it
(2) European Union Commission, Joint Research Centre, Institute for the Protection and Security of the Citizen, G07, Monitoring, Control and Traceability in the Food Chain, via Enrico Fermi 2749, 21027 Ispra, Varese, Italy

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the prevention of fraud.

The system enables the competent authorities to perform more targeted and efficient controls on transport to ensure the uniform implementation of the above Regulation within the European Union. The navigation system creates the possibility for a totally different approach to the organisation and implementation of veterinary controls. Currently, due to the lack of modern tools, the competent authorities of European Union member states monitor the implementation of Regulation 1/2005 by inspecting circulating trucks in collaboration with police authorities. The aim of monitoring activities is to verify the compliance/non-compliance by inspecting the conditions of animal transport and the relevant accompanying documents. However, those controls are not targeted to specific cases of non-compliance.

Instead, the navigation system enables the authorities to implement much more targeted controls, investing present resources in a number of non-compliant cases that have been detected by the system itself at the headquarters of the authorities before the inspection takes place.

Available technology enables the integration of temperature monitoring with positioning and recording into the navigation system, avoiding duplication of devices and information and allowing the shared use and simplification of systems. A communication system is capable of sending stored data to a remote receiver from the transport vehicle at regular intervals and/or when certain events occur. One of the possible options in a future scenario is to transmit the relevant information to a central, remote receiver from which the data can be displayed according to strict access rights (e.g. transport companies may see their own data, competent authorities the data for their jurisdiction).

In terms of livestock traceability, there is also a need to link the information collected by the satellite navigation system with data made available in the Trade Control and Expert System (TRACES), the European Union's information system which establishes communication between member states for animal trade purposes. The single batch of transported animals, identified with a TRACES number and accompanied by the relevant veterinary certificate, can therefore be monitored constantly throughout the journey.

The impact assessment on the navigation system carried out by JRC (awt.jrc.it) demonstrated that a central, European Union-wide receiver and database would have clear advantages compared to other options (the least expensive with most advantages). However, the final scenario on the architecture of data transmission (local/national/community database, communication standards, etc.) has still to be discussed and approved in the appropriate forum.

Overview on the features of the final system

Any navigation system that conforms to the requirements of Regulation (EC) 1/2005 (3) consists of a global navigation satellite system which locates the vehicle and provides precise timing. These data should be recorded regularly and stored in an onboard unit which can collect, record and store the regularly monitored temperature in the animal compartment, the status of the loading doors and can finally generate warnings when reaching predefined temperature thresholds.

Through an interface, the driver of the transport will be able to enter into the onboard unit predefined sets of information, such as, for instance, category, species and number of animals loaded, start and end of a journey, number of animals injured/dead during transport, TRACES number of the batch, etc. The interface will also provide warnings to the driver when the temperature in the animal compartment reaches certain thresholds. The onboard unit should be able to continue operating when disconnected from the external power supply for a predefined time span. It will store data collected during a journey for at least four weeks and allow authorised users to download the data. A communication system sends the stored data at regular intervals and/or when certain events

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occur to a remote site. By standardising the data format, animal welfare data for specific journeys will be made available (e.g. through Web services). The integrity of the data is guaranteed.

Data to be regularly collected, logged and communicated to a remote receiver

The following data must be collected, logged and transmitted at regular intervals:

- position of the vehicle
- time
- temperature in the compartment in which the animals are transported.

The data blocks are distinguishable by time stamp and onboard unit identification.

Events to be communicated to a remote receiver at variable occurrences

The following events can be collected, logged and transmitted when they occur or can be entered into the system at one time:

- journey event (start, rest, resume, end of journey, loading and unloading of an animal batch, i.e. the group of animals accompanied by a specified veterinary certificate and identified by a specified TRACES number: more than one batch can be transported in the same vehicle)
- species and category of animals loaded for each batch
- number of animals loaded for each batch
- opening/closing of the loading doors
- coupling/uncoupling of semi-trailer/tractor or truck/trailer
- number of animals injured or dead during or after the journey
- login event or download event (servicing, inspection)
- tampering or malfunction event, such as disconnection from power, sensor failure, low battery status, opening, removal of the onboard unit.

The prototype project

Since 2006, the JRC and IZS A&M have been working together on a project designed to verify the feasibility of a system in which data collected from an equipped vehicle fleet are transmitted to a predefined remote database.

The navigation system is designed to collect, record and transmit a defined set of data as specified by DG SANCO (2). It consists of the following hardware components for the required functions:

- the onboard unit (Fig. 1) is equipped with the following:
  - a general packet radio service (GPRS) module which enables the transmission of the data to a remote receiver
  - a global positioning system (GPS) module that records time-referenced vehicle position data and travelling time
  - memory (for internal data storage)
  - serial port for the connection with additional devices (for instance, radio-frequency identification [RFID] readers, etc.)
- temperature sensors
- loading door sensors
- trailer sensors.

The present configuration enables up to 32 connections with sensors.



Figure 1
The onboard unit

The cabin user interface provides information on the status of the system, including warnings. In addition, it provides the driver with the possibility to input data when additional information should be entered.

All parts are interconnected. The hardware enables expansion for further sensors, e.g. for measurement of humidity.

The system is autonomous and operates in both the presence and absence of external power on the truck/trailer, as the system is equipped with rechargeable batteries.

Hardware configuration overview

The system must be compatible with different types of long journey animal transport vehicles. The onboard unit is preferably installed in the part of the vehicle equipped with animal compartments to monitor the welfare conditions of the animals being transported and also to record if the trailer is uncoupled.

For instance, Figure 2 shows a simplified overview of a system in a semi-trailer with a tractor configuration.

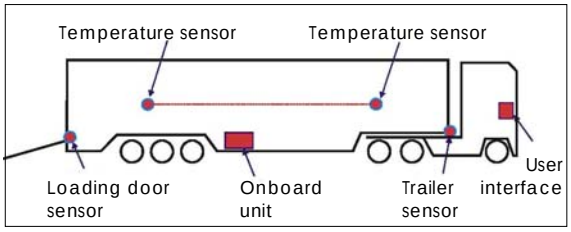


Figure 2
Onboard unit installation on a semi-trailer

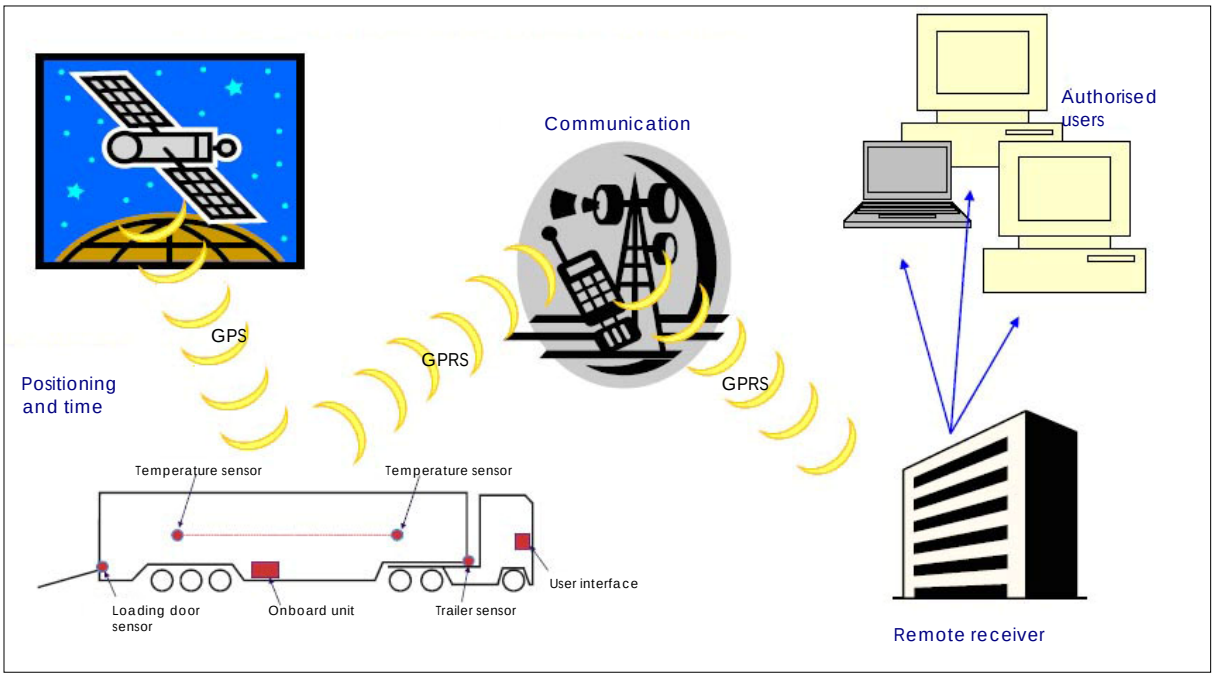
Software components of the prototype and data flow

The onboard unit transmits data collected from the GPS module and from the truck sensors to the remote receiver via the GPRS module (Fig. 3). The stored data can be sent at regular intervals and/or when certain events occur (asynchronous events, such as high or low temperatures, open or closed status of loading doors, tampering or malfunctions). Each data block is distinguished by a journey identification, data block identifier, name and authorisation of transporters.

Onboard unit transmissions

Communication between the onboard unit and the remote receiver is performed using XML and Web service technologies. Details of these technologies are available (6, 7).

The onboard unit performs a Web service call sending data as an XML data stream. Thereafter, the XML format is validated using an XSD file which contains rules for accepting or refusing information transmitted by the onboard unit. In particular, it describes the



GPS global positioning system
GPRS general packet radio service

Figure 3
Data flow: principal technical architecture

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node and related attributes that is permitted in the XML data stream.

Figure 4 shows the basic elements of the XSD file.

More precisely, the 'blk' node is the root node of the XML data, the 'vin' attribute stores the onboard unit identification number. A 'blk' node contains the following:

- a pos child node (which stores the geographic position of the onboard unit)
- an onboard unit child node (which stores data related to the onboard unit).

The onboard unit subtree is given in Figure 5.

The tree node provides information on the status of the journey. In particular, the journey status attribute indicates the state of the journey as being either started or finished. The tan node provides information on the animals transported. The list of all possible values for the tan node is reported in the same figure. Each value indicates a different category (e.g. 'tan=pu3u' corresponds to 'pig's weight <30 kg').

The remote database that receives onboard unit transmissions was set up at the Italian animal identification and registration system database (*banca dati nazionale*: BDN) managed

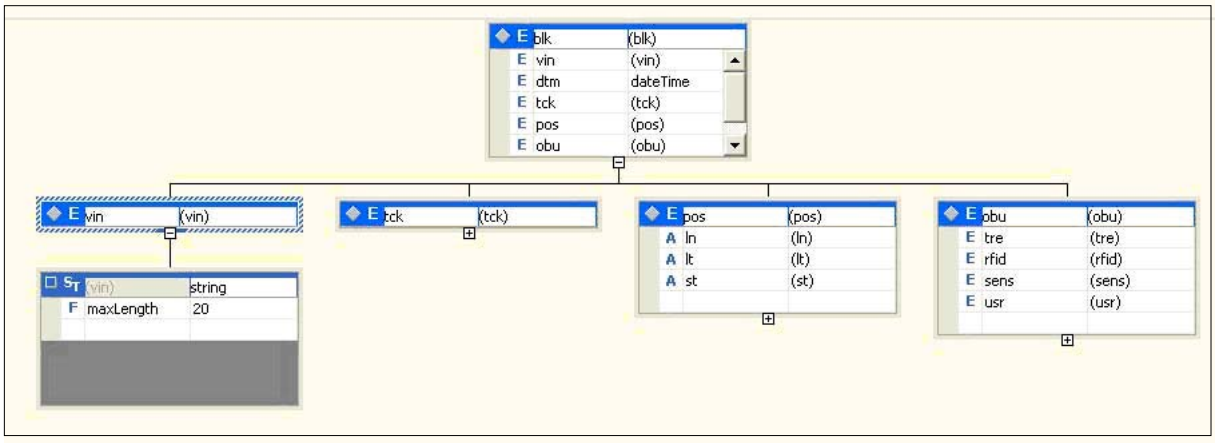


Figure 4
XSD tree

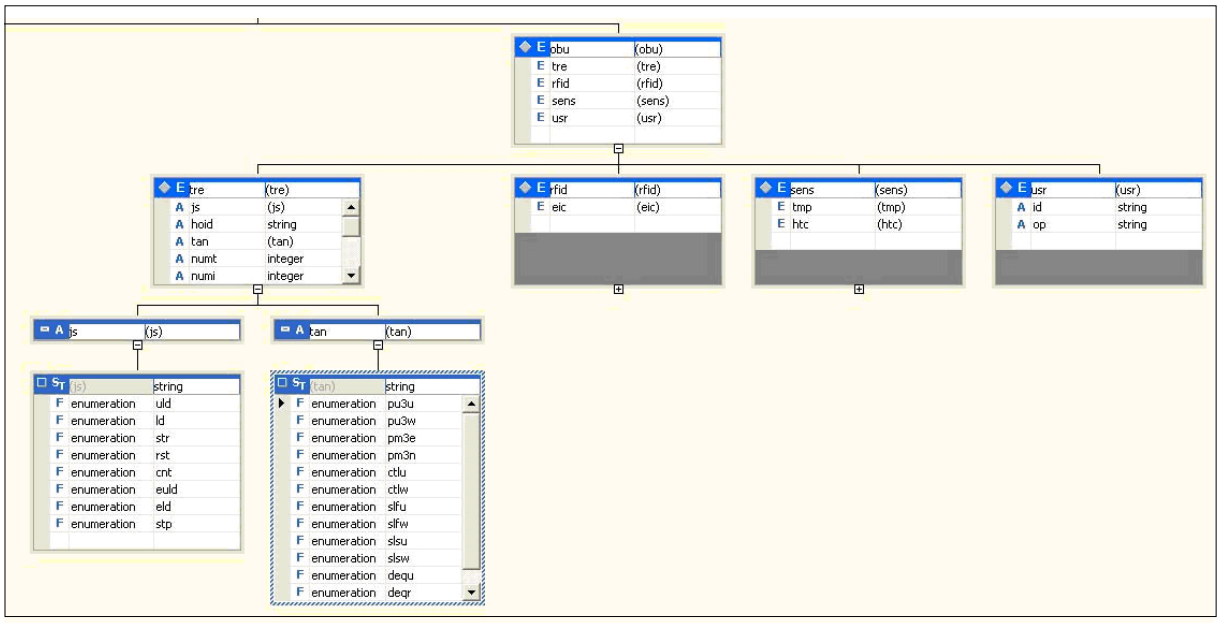


Figure 5
XSD tree detail

by the IZS A&M. The communication with the onboard unit is ensured by the interoperability system at BDN site (1).

Web application

The data transmitted by the onboard unit and received by the BDN are accessible real-time and can be analysed on the Web using a Web-geographic information system (GIS) application.

Data are visible only to authorised users. In particular, a transport company can see the data related to the trucks of its fleet. An authorised organisation of a European Union member state can visualise the data related to the trucks passing across the territory of the state. The administrator can access all data.

Up-to-date information is available through a visual and intuitive user interface. This allows the decision process to be more rapid, efficient and targeted to the spatial area of interest. Indeed, the application provides a number of functions which are very useful for the analysis of data, namely: position data can be filtered by interval of date, by truck, by transport company and by state (Fig. 6).

Moreover, data can be seen through a Web-GIS interface which graphically illustrates the following:

- the path of a journey (Fig. 7)
- the position of the truck when in motion and where parked
- the location of the truck when the loading door is open
- the position with anomalies of any nature, e.g. where the loading door of the truck is open and the speed is greater than zero.

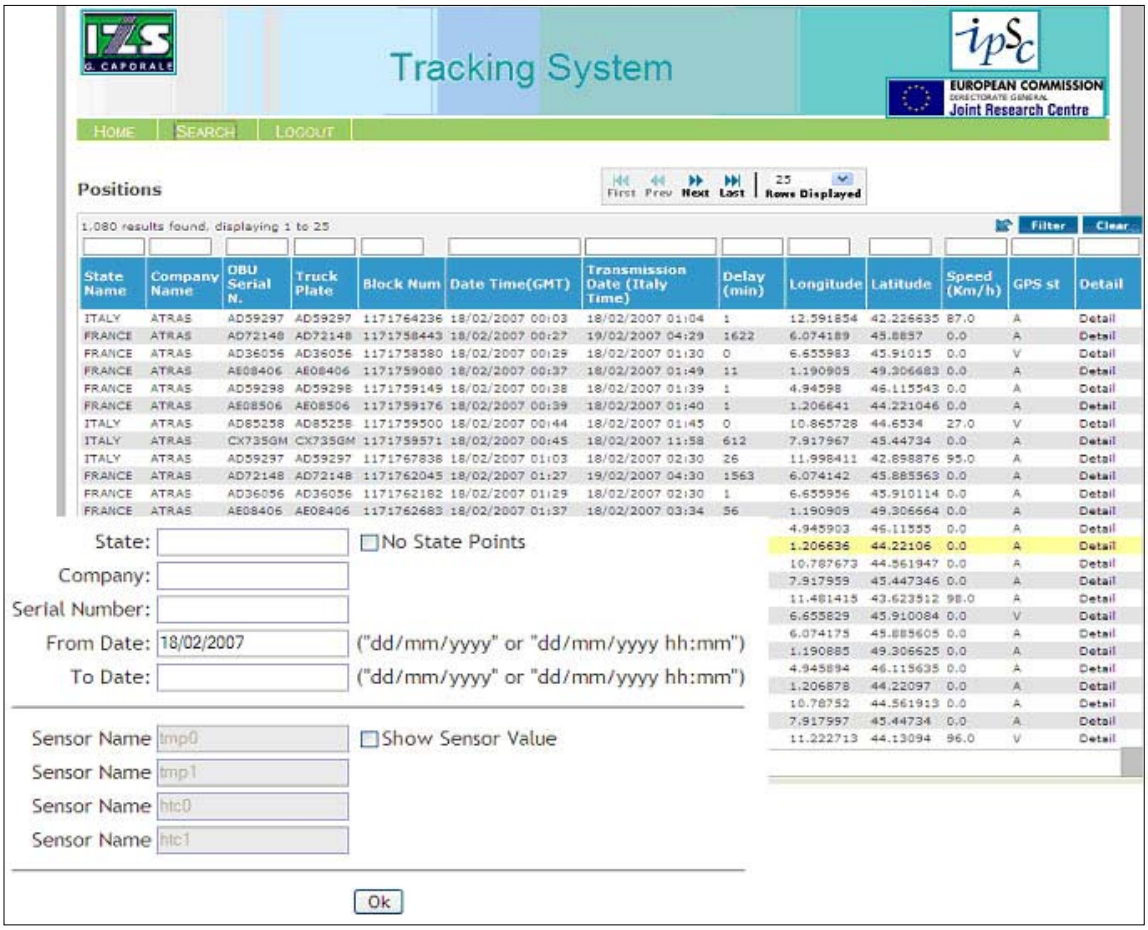


Figure 6
Filtering position data

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Figure 7
Graphic representation of information on the position of a truck

Journeys

An animal transportation starts when an empty truck and a consignment of animals is loaded at a given site and it ends when the last animal is unloaded.

In our system, the driver manually sets the start of a journey by interacting with the cabin user interface. This triggers an onboard unit transmission notifying the commencement of travel.

During the journey, the onboard unit reads the position and sensor's value and regularly sends these to the BDN. At the end of the journey, the driver manually sets the termination of the journey by interacting with the cabin user interface. This triggers an onboard unit transmission notifying the status.

In the Web application, the journeys are monitored and dates, times and locations of starting and stopping are indicated (Fig. 8).

The details of a journey include the entire set of onboard unit transmission between the commencement and termination of a journey (Fig. 9).

Web-geographic information systems technology

The technology used to graphically report points related to onboard unit transmissions on a map is based on two principal software frameworks, namely: Google™ maps [Google™] and OpenLayers [OpenLayers] (4, 5) (Fig. 10). The most significant difference between the two technologies is essentially that OpenLayers is an open-source project, whilst Google™ maps requires a license for commercial purposes.



Figure 8
Journey report

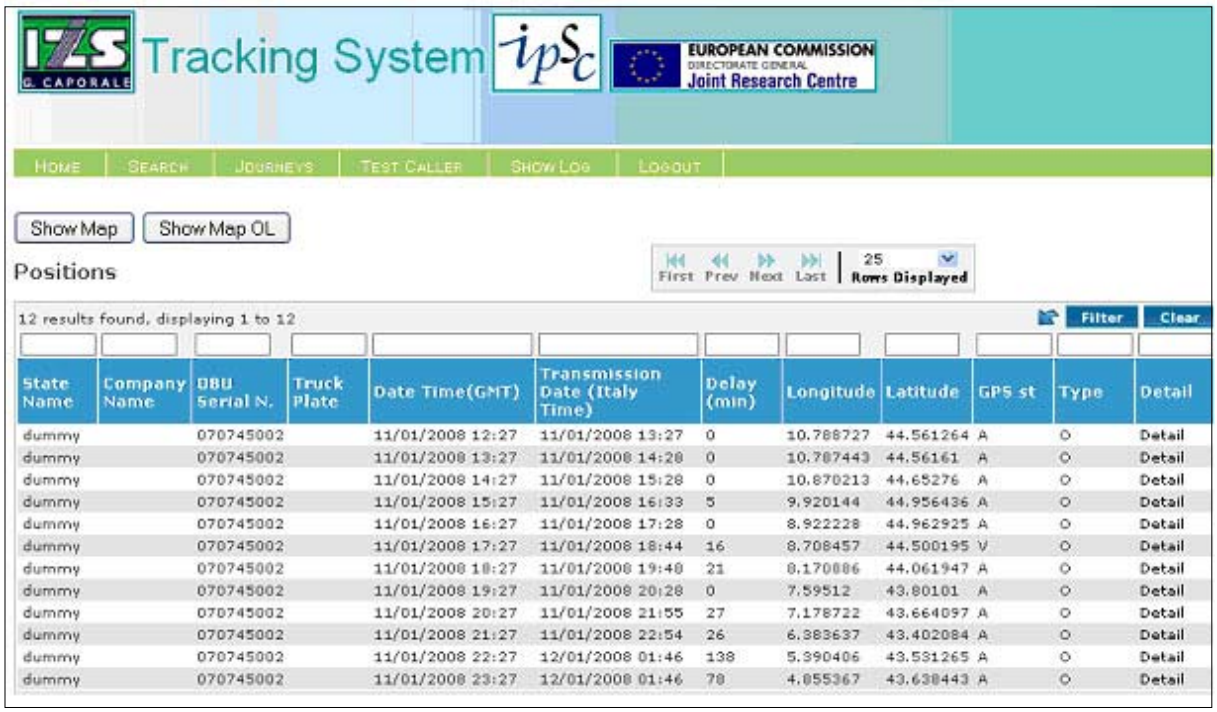


Figure 9
Data of a journey in tabular format

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Figure 10
Graphic details of a journey

Transmission logs

Another important feature of the Web application is the log view tool. Each message sent to the Web service is stored in the database. The complete list of data transmitted can be filtered by transmission date. This function can show transmissions that have been accepted, correctly validated or refused. An 'error' field reports possible anomalies.

Figure 11 shows examples of accepted and refused transmissions (the latter because the XML data was validated with respect to the XSD file). The error reported is: 'XML document invalid'.

This feature is an essential tool in such an asynchronous and decentralised environment. It helps to debug possible communications problems, such as invalid XML format, delays in transmissions, unpredictable onboard unit behaviour and much more.

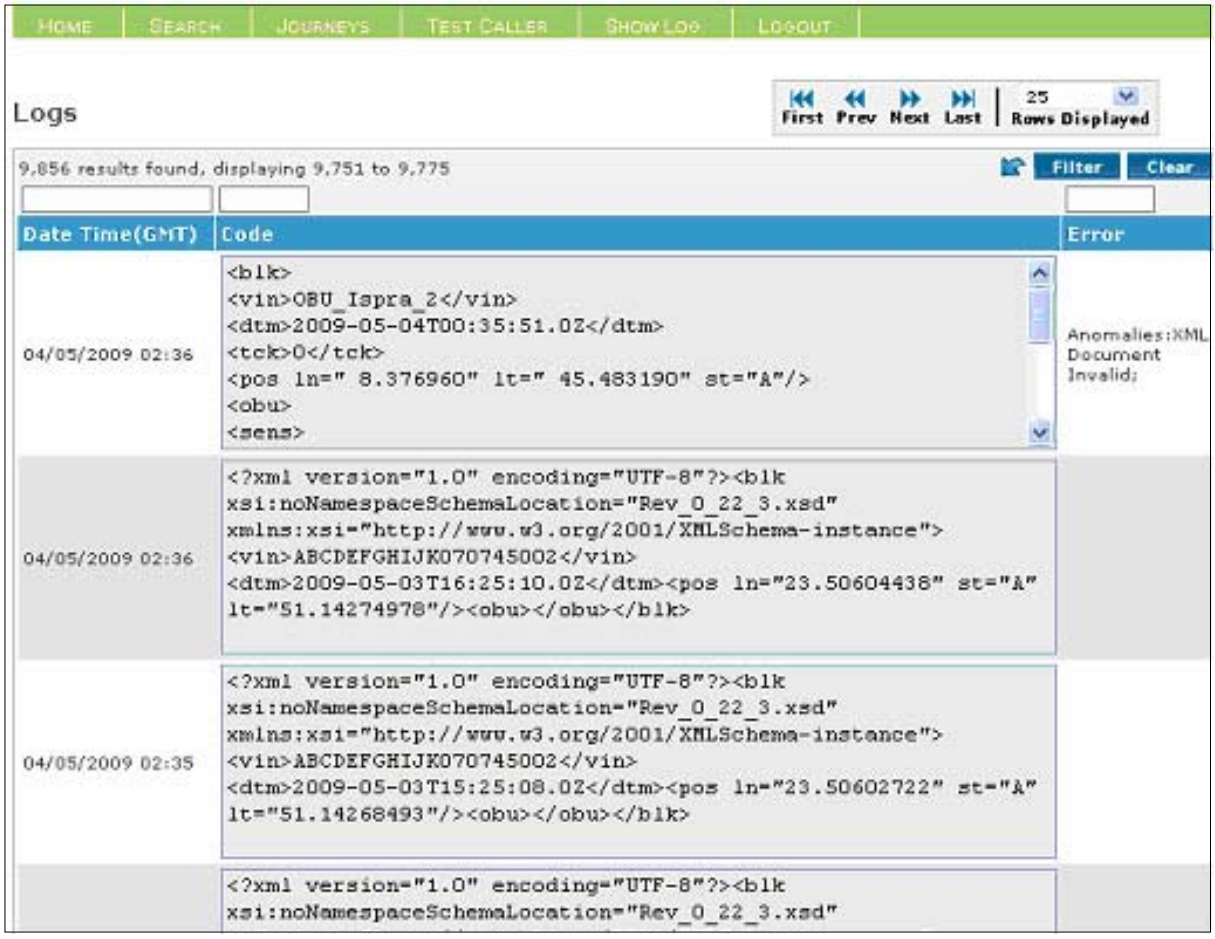


Figure 11
Logs

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