Quality management for the road transportation of livestock

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Summary

Transport can be a significant stress factor for livestock and can result in poor animal welfare and economic losses. Quality management measures are actively employed in fields different from animal welfare and could be applied to improve the welfare of animals and reduce the consequent losses during road transportation and related activities Training and education of staff comprise one possible measure, Web-geographic information system technology used to monitor the true state of transported animals is another innovation that promises major progress. With this technology, behavioural and environmental parameters can be monitored and registered in real time. The resulting data could be useful to control the transport environment and the conduct of staff. Although some parameters cannot be represented through numerical relationships, behavioural and environmental measurements can be used in a risk analysis system to minimise risks of poor welfare during animal transportation. The European Union Joint Research Centre and the *Istituto Zooprofilattico Sperimentale dell'Abruzzo e del Molise 'G. Caporale'* in Teramo are working on an experimental project to prove the feasibility of a navigation system for long road journeys as referred to in Regulation (EC) 1/2005 of the European Union. Such a system enables the collection of data on transported animals and the verification that welfare requirements are being met at any given moment during the journey.

Keywords

Animal, Geographic information system, Quality, Management, Road, Technology, Transport, Web, Welfare.

Gestione della qualità nel trasporto su strada di animali da produzione

Riassunto

Il trasporto può essere un significativo determinante di stress per gli animali da reddito, con ripercussioni negative sul benessere animale e conseguenti perdite economiche. Diversi interventi finalizzati al controllo della qualità vengono comunemente messi in atto in altri settori, e potrebbero essere impiegati anche per migliorare il benessere degli animali e ridurre le perdite economiche legate al trasporto ed alle procedure ad esso correlate. La formazione e l'addestramento del personale, così come l'introduzione della tecnologia web-GIS per il monitoraggio delle effettive condizioni di trasporto degli animali, potrebbero apportare un significativo progresso in questo campo. Questa tecnologia permetterebbe di monitorare e registrare in tempo reale i parametri di benessere comportamentali ed ambientali. I dati ottenuti potrebbero essere utili per controllare le condizioni ambientali di trasporto e la corretta condotta del personale. Benché alcuni parametri non siano riportabili in forma numerica, è possibile utilizzare le misurazioni comportamentali ed ambientali in un sistema di analisi del rischio, al fine di minimizzare i rischi di uno scarso benessere

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*durante il trasporto. Il JRC (*European Union Joint Research Centre*) e l'Istituto Zooprofilattico Sperimentale dell'Abruzzo e del Molise "G. Caporale" di Teramo, stanno sviluppando un progetto sperimentale per dimostrare la fattibilità di un sistema di navigazione per trasporti su strada su lunga distanza, come previsto dal Regolamento (CE) 1/2005 dell'Unione Europea. Un sistema di questo tipo permette di raccogliere informazioni sugli animali trasportati e di verificare che le condizioni di benessere siano rispettate in ogni momento del viaggio.*

Parole chiave
Animale, Benessere, Geographic information system, Gestione, Qualità, Strada, Tecnologia, Trasporto, Web.

Introduction

Quality management is important in maintaining a high level of animal welfare in road transportation of livestock. The level of quality of animal welfare in road transportation depends on both human-animal interactions and the environment of the transport vehicles. Good caretaker behaviour when handling animals is a basic requirement (1), but physical conditions of transport are also of the utmost importance. According to the *Terrestrial animal health code* of the World Organisation for Animal Health (Office International des Épizooties: OIE) (56), the correct handling of animals to reduce their fearfulness and improve their approachability is preferable to the administration of behaviour-modifying compounds, such as tranquillisers.

Quality management measures are largely employed in fields other than animal welfare to ensure acceptable levels of safety and to minimise risk. Risk analysis is highly effective in the management of food safety and is based on the monitoring of certain parameters. A similar approach can be applied to farm animal welfare (16). Physical health, production traits, physiological indicators and behavioural indicators (45) are useful for this purpose. In some cases, these parameters cannot be quantified, particularly behavioural indicators, which complicates the application of risk management. However, a number of quality management measures can undoubtedly be used to improve animal welfare.

The new European regulation on protection of animals during transport (17) introduces systems to ensure acceptable levels of animal welfare quality during road transportation. These include geographic information system (GIS)/global system for mobile communications (GSM) technology, temperature monitoring systems and the training and education of drivers. However, quality management of livestock transportation could be extended further and include other factors that influence animal welfare and which could technologically be monitored in real time by technological means during transport. In this regard, the Joint Research Centre (JRC) of European Union (10) is implementing a project to develop an integrated system to provide real time information on animals, which verifies that animal welfare standards are being respected at any given moment during a journey.

Transport quality and stress

Livestock are transported at various times during their lives. Depending on species and country, there are significant differences in the number of times and the conditions under which animals are transported. For example, in the United States and Europe, poultry are usually transported over short distances because poultry production is often integrated and managed by a single company (47). On the other hand, cattle are often transported over very long distances. For example, a large proportion of cattle bred in France are slaughtered in neighbouring countries, such as Italy or Spain (11). Weaned calves and yearling cattle are often transported thousands of kilometres to feedlots; this occurs in both the United States and Europe. Vehicles transporting pigs bred in one country (e.g. Belgium or Holland) and slaughtered in another (e.g. Italy) also travel long distances. Very young pigs are now often transported from their native farm to piglet rearing farms.

Several stress factors may have an effect on transported animals. According to Gonyou (23), transport and handling operations may involve two distinct types of actions, namely: direct movements and restraint. Neither of these is part of the normal experience of an animal, so they can be great stressors. Livestock are forced onto a vehicle by people they have never seen before, are often mixed with unknown animals, surrounded by unknown noises and subjected to vibrations they have never previously experienced. Gonyou (23) states that 'even our first astronauts were told to expect weightlessness during their flights, but our animals must move through chutes and ride in vehicles without prior explanation'. Moreover, transported animals are often subjected to environmental stressors, such as heat stress, confinement, food and water deprivation, that undoubtedly increase their discomfort. In these cases, good transport management and correct farming practices can relieve some of that discomfort.

Animals that are used to handling and to close contact with people are usually less stressed by restraint and handling linked to transport than animals that see people infrequently (56). Training calves, walking among them, teaching them to follow lead horsemen and, generally, handling animals early in life produce calmer adult individuals that are easier to handle (26). Operators who handle animals during the activities related to transport (both movement and restraint) should follow some simple rules to minimise stressors. Movement is accomplished by making the target location and the route to it more attractive than the starting location, providing more light and space, and also social contact (23). Stimulating movement making the starting location aversive by provoking fear and discomfort (shouting and beating) simply increases stress. If animals are not excited, they show a degree of natural curiosity that can be employed to direct movement (23, 29).

Several different behavioural features should be considered when handling animals for transport. The most important of these are the flocking instinct, visual field and flight distance. Flocking instinct is strongest in sheep, but cattle and swine can also seek safety in a group when frightened.

Compatible groups should be selected before transport; specific guidelines are available for assembling groups of animals for transport (56). Animals reared together should be placed in the same group. Young animals should be separated from older animals and animals without horns should not be mixed with horned animals. The formation of groups of unfamiliar animals may cause agonistic behaviour, fighting and poor animal welfare (42). However, once the social organisation has been established, fighting diminishes. It is useful to place animals in groups for two to three days prior to transportation, so as to allow them to become familiar with each other, thus minimising the stress of transport.

The concepts of 'visual field' and 'flight zone' may be employed to facilitate animal handling. According to Grandin (25, 27), handlers should position themselves 45°-60° from directly behind the animal and on the edge of their visual field. In fact, animals follow the direction of their visual field only if the handler does not remain in this area. Moreover, handlers should know the 'flight zone', i.e. the distance at which animals react by fleeing. If handlers keep to the edges of the visual field and flight zone, they can control animal movements with ease and respect their welfare at the same time. Behaviour-modifying compounds (i.e. tranquillisers), should not be used routinely during transport and should be employed only on individual animals in specific conditions (56).

The environment within the means of transport can be an important source of stress and it is relevant that the welfare of an animal has been described its 'state as regards its attempts to cope with its environment' (20). Attempts to cope with pathologies are part of welfare. So, health is part of welfare and environment can greatly influence the health of an animal. During transportation, animals may have more difficulties in coping with the environment because of social stresses, lack of space and other unknown and unaccustomed

factors (2). However, thermal stress is the major problem for transported animals. This can be evaluated using a number of parameters that can be measured and regulated with appropriately designed technology on a vehicle used for transportation.

Some studies have also focused on other environmental factors that may affect animal welfare during transport, particularly movement and vibration resulting from routes with numerous curves and corners or careless driving (4, 31, 50). The way in which animals are loaded and unloaded as well as the way in which a vehicle is driven can have enormous effects on the welfare of transported animals (3, 44).

Training courses and certificates of competence are required for drivers and attendants in many countries, through mandatory laws (i.e. Europe) or codes of practice (i.e. Australia and New Zealand). According to the OIE guidelines for the transport of animals by land (56), the competence of animal handlers should be described in a certificate issued by a 'competent authority' or from an accredited independent body. This is also provided for in European Union Regulation 1/2005 which states that training courses should include, among other things, practical aspects of the handling of animals and an understanding of the impact of driving behaviour on the welfare of transported animals (17). The method of payment of drivers and attendants can be of considerable importance for welfare during transport (1). Bonuses have been suggested for reducing fuel consumption, so as to encourage slower driving with fewer accelerations (30). Bonuses given for meat quality upon delivery of the animals (for example a limited number of dark firm dry [DFD] or pale soft exudative [PSE] cases) can also be used to improve animal welfare (13, 28).

Suffering from stress prior to slaughter has recently gained considerable importance in regard to both animal welfare and economic impact. Mortality and carcass damage is often associated with poor quality management during transport: Losses due to transport have been reported to be 0.06% in pigs (0.3-0.5% for stress-susceptible breeds), from 0.06% to 0.3% in poultry and up to 1% in cattle. In the United States, death losses during transport are mostly due to shipping fever (47). Transport management also has a significant impact on carcass quality. Trauma can lead to the downgrading of carcass quality and value. In addition, physiological changes may influence meat quality, resulting in PSE meat in swine and DFD meat in cattle. In Italy, an important cause of economic loss for the swine meat processing industry is the rejection of legs affected by micro-haemorrhages and haematomas (over 23% of all rejection cases) These legs cannot be used to produce high quality products such as the famous cured hams, *prosciutto di Parma* or *prosciutto di San Daniele* (35).

Risk analysis for animal welfare

A recent report of the Scientific Panel on Animal Health and Welfare of the European Food Safety Authority (EFSA) (16) proposed the use of risk analysis systems in animal welfare. A risk assessment approach along the lines suggested at the 22nd Session of the Codex Alimentarius Commission was applied to intensive calf farming (7). These guidelines, originally formulated to assess micro-biological, chemical or physical risks, were adapted to evaluate animal welfare. The various factors that potentially affect the welfare of animals were assessed in regard to whether or not they constituted a hazard or potential risk. Each selected hazard was evaluated for risk severity and the likelihood of occurrence; risk managers then used the results in a search for mitigation measures. A lot of data can be represented qualitatively but not numerically and it was not possible to perform a risk assessment in an entirely quantitative way. A risk characterisation score (hazard characterisation × exposure assessment) was assigned to each hazard to classify them from 'moderate' to 'very serious'.

This risk analysis approach could be applied with ease to animal welfare during transport and could use data collected on vehicles. Limits similar to those accredited for intensive

calf farming could be established, especially for the qualitative rather than quantitative measurement of behaviour. Environmental measurements could certainly be quantified and assigned to an objective risk characterisation score.

Animal welfare assessment

Several measurements can be made for assessing the welfare of transported livestock. Opinions and reports of the European Commission and EFSA (9, 13, 14, 15) have stated that behavioural, physiological and biochemical measures are possible. Incidences of injury, morbidity and mortality at the end of transportation and the condition of carcasses can also be significant. Standards for the microclimate within a transport vehicle can be defined with accuracy (13). Real time measurable parameters gain particular importance in the application of microclimatic measurements on vehicles.

Behaviour, the most obvious indicator of animal stress during transport, can sometimes not be assessed in an entirely objective way but is amenable to reliable subjective assessment. Environmental parameters can be measured easily and objectively. Both behavioural and environmental measurements can be made in real time measurements of behaviour and the environment of a transport vehicle can be made with a closed circuit camera for behaviour and conventional instruments can be used for temperature and humidity, air velocity and concentrations of CO_2 and ammonia. The use of accelerometers to measure the effects of vehicle movements has also been suggested (50). All these useful data can be collected and transmitted in real time to databases for recording and compilation. An integrated navigation and monitoring system is being developed by a European Community-funded research project to determine the possibility of collecting and transmitting data both on vehicle position and animal welfare (10).

Measurements of behaviour

Changes in behaviour are useful indicators of welfare during animal transport. Behavioural responses can vary greatly from one species to another, and also from one individual to another (46). When subjected to stress factors, animals may stop moving forward, freeze, back off, run away or vocalise (1). Differences in behavioural responses depend on the selection pressures that have had an effect during the evolutionary process and experience of the individual (1).

According to some authors (1, 32, 36), individual animals can be categorised according to the nature of their responses. Studies on this individuality of responsiveness, mostly with swine, suggest tests that may reveal whether or not an animal is likely to be severely affected by transport (43).

Individuals of different species show their discomfort during transport in different ways. Kilgour (39, 40) studied the effects of different modes of transport for sheep and in cattle, while other authors (44, 52, 53, 54) have considered pigs and horses. Kilgour found that if cattle being transported by road are allowed to settle down at the beginning of their journey they will travel without difficulties. The lowering of the head is the sign that the animal has settled and this must happen as soon as 30 min after travel commences (39). Another sign of wellbeing is that cattle tend to bunch their heads to the centre, thus avoiding contact with pen walls. At the beginning of a journey, cattle are anxious and restless and defecate and urinate frequently (42). If stressed, cattle do not readily lie down and this forced standing causes them to become physically tired. A loss of balance can result and is a major determinant of injuries of cattle during transport, particularly if the route has many corners and the driver is not careful. Cattle, sheep and horses endeavour to stand in a vehicle in such a way that minimises the chance of being thrown around. They do not lean on other individuals and are significantly disturbed by too much movement of a vehicle (3).

The assessment of animal behaviour to accredit comfort on transport vehicle is possible with closed circuit cameras mounted in pens and connected to a time-lapse video in the cabin (22). Images can be recorded for up to 24 h. Transporters with adequate competence will benefit from valuable information from these instruments that enable them to adjust their driving according to the behaviour of animals in the vehicle. Moreover, these images can be recorded and transmitted real time to a control centre or they can be made available to a competent authority upon request when monitoring the conduct of the driver.

Measurement of the environment

Environmental measures can also be assessed on an animal transport vehicle. There is a strong relation between the environment of an animal and its health and welfare. Temperature and other factors which contribute to heat stress are crucial to the welfare of animals that are being transported. Webster (55) classifies farm animals into two groups according to their ability to regulate body temperature. Those with limited ability are pigs and poultry. Those with the highest ability are cattle, sheep and horses.

Two possible environmental targets which apply to an acceptable level of animal welfare are the thermo-neutral zone and the zone of thermal comfort (34, 55). The neutral zone is a wide range of temperature in which metabolic heat production is independent from air temperature. The zone of thermal comfort is that which an animal would select for itself; this is narrower than the neutral zone.

The new European regulation provides for the presence of temperature monitoring systems on transport vehicles. However, temperature is not the only parameter that contributes to the thermal state of an animal. Heath stress results from any combination of measurable environmental factors (i.e. air temperature, humidity, air movement, solar radiation) that produce an effective temperature that is higher than the temperature range of the animal's thermal neutral zone (21, 49). There are different methods that can be used to assess heat stress, from complex to simple. A simple method can be achieved by quantifying the temperature humidity index (THI). This index combines the effects of temperature and humidity into a single value. It was originally developed for the evaluation of heat stress in animal production conditions, but can also be applied to transportation conditions (33). Different formulas are used to calculate this index. For example, Kliber's formula (41) which considers the variables of air temperature (°C) and air humidity (%): THI=[1.8 × temperature–(1-humidity/100) (temperature-14.3)]+32.

Kliber classifies different levels of heat stress for livestock on the basis of different THI values, namely: the scale extends from THI=68 (minor stress) to THI=84 (emergency). The livestock safety index (LSI) (8) used by several agricultural weather agencies to alert farmers on weather conditions that could potentially danger their livestock, is based on THI and has only three stress categories (alert, danger and emergency). Common thermometers and hygrometers installed on a transport vehicle could provide good control of the effective thermal comfort of the animals. The use of hygrometers to evaluate the THI could be an effective improvement compared to European Regulation (EC) 1/2005, which provides only a temperature monitoring system. However, some difficulties could be encountered in measuring these environmental parameters, in particular: according to the opinion of the Scientific Panel on Animal Health and Welfare (13), humidity sensors will not tolerate direct contact with water, as might occur when the vehicle is washed. Therefore, these sensors should be adequately protected and positioned to avoid direct contact with water. Practical experience showed that most hygrometers cannot measure values above 95% air humidity. Kettlewell (38) reports that hygrometers often display 'failure' or 100% when conditions are above 95% air humidity. However, all these technical problems can be resolved by finding an adequate sensor position and using more accurate and robust instruments.

To complete the microclimate monitoring on a vehicle, it may be possible to install other devices, such as probes for measuring the velocity of the air and instruments to monitor ammonia and CO_2. Anemometers should be placed in the same position as temperature and humidity sensors and may display data in addition to THI. Instruments to measure ammonia and CO_2 are costly and require that the driver has special training in their use (13), but they could be useful when evaluating the efficiency of the ventilation system (5, 6). A number of studies have been published on this subject, mostly on pigs, showing the importance of efficient ventilation for the microclimate of a fully loaded vehicle, where both temperature and gas concentrations are controlled (5, 37, 51).

Forces of motion can also influence the comfort of animals during transport. Rough journeys are more stressful for animals, as demonstrated by studies evaluating differences in cortisol values, heart rate and meat quality (4, 50). This research used an accelerometer which could be complemented by a closed circuit camera to measure rough accelerations and braking. The accelerometer was able to record all changes in acceleration of more than 7 m/s^2. The increment of the number of accelerations can be related both to the number of corners in the road and to the carelessness of driving.

Ongoing research: navigation system to monitor animal welfare during long journeys

Within the framework of administrative arrangement No. 30042-2005-12 A1CO between the European Union's Directorate General for Consumer Protection (DG SANCO) and the JRC, the JRC is conducting a project entitled 'animal welfare in transportation'. This project provides technical support to DG SANCO in establishing an effective navigation system in accordance with Regulation (EC) 1/2005 on the protection of animals during transport (18). To achieve better enforcement of the standards, the objectives of the project are to develop a navigation system for long road journeys, as referred to in Regulation (EC) 1/2005, which provides for demonstration and verification (at any given moment during the journey) that animal requirements are being respected.

By recording and transmitting certain animal welfare parameters during the journey in real time, the system provides livestock transporters with a tool to facilitate compliance with animal welfare requirements in transportation, to lessen the administrative burden for transporters and competent authorities and to contribute to the prevention of fraud. The system could enable competent authorities to perform more targeted, effective and efficient controls on animal transport and to ensure the uniform enforcement of Regulation (EC) 1/2005 within the European Union (19).

Regulation (EC) 1/2005 does not necessarily require a connection between the temperature monitoring and recording system and the navigation system on animal transport vehicles. However, the technology available enables the integration of the temperature monitoring and recording into the navigation system, thereby avoiding duplication of devices and information and enabling shared use and simplification. A communication system is able to despatch stored data from the transport vehicle at regular intervals, and/or when certain events occur, to a remote receiver. Consultations with the competent authorities and stakeholders during the preparation of technical specifications showed that a clear majority favoured a central, Community-wide remote receiver from which data could be visualised with strict access rights (e.g. transport companies may see their own data, competent authorities may see the data for their own area). There was also a strong interest from Commission services, authorities and stakeholders to link the information collected by the satellite navigation system with data made available in the trade control and expert system (TRACES) (12). The *Green Paper* of the Commission on satellite navigation systems also indicated a preference for this link.

An economic impact assessment on the system conducted by the JRC demonstrated that a central, Community-wide receiver and database would offer clear advantages over other options and would be the least expensive with most advantages. The Commission service operating TRACES expressed a strong interest to host the remote receiver and database for the satellite navigation system. The final decision on the extent of availability of data collected by the satellite navigation system has yet to be proposed by the Commission and approved by the member states of the European Union.

Overview of the specifications of the final navigation system

Any navigation system that conforms with the requirements of Regulation (EC) 1/2005 and with the DG SANCO working document for long journey animal transportation must include a global navigation satellite system which locates the vehicle and provides precise timing. The data must be recorded regularly and stored in an onboard unit which collects, records and stores the regularly monitored temperature in the animal compartment, the status of the loading doors and creates warnings when predefined temperature thresholds are reached.

The driver of the vehicle must be able to use a computer interface to enter data into the onboard unit, i.e. predefined sets of information, such as category, species and number of animals loaded, start and end of a journey and the number of animals injured/dead during transport. The interface also provides warnings to the driver when the temperature in the animal compartment reaches permitted thresholds. The onboard unit must be able to continue operating when disconnected from the external power supply. It must store data collected during a journey for at least four weeks and allow authorised users to download the data. A communications system must be provided to despatch the stored data to a remote site. By standardising the data format, animal welfare data for specific journeys could be made available (e.g. through Web services). The integrity of the data must be 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:

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

The data blocks must be distinguishable by a journey log number, data block identifier, name and authorisation of transporter.

Events to be communicated to a remote receiver upon occurrence

The following events must be collected, logged and transmitted when they occur or once they have been entered into the system:

- status of journey (start, rest, resume, end of journey)
- species and category of animals loaded
- number of animals loaded
- opening/closing of the loading doors
- coupling /uncoupling of semi-trailer/tractor or truck/trailer
- number of animals injured or dead during or after journey
- login event or download event (servicing, inspection)
- tamper or malfunctioning event, such as disconnection from power, sensor failure, low battery status, opening, removal of the onboard unit.

The data must be distinguished by a journey log number, data block identifier, name and authorisation of transporters.

The prototype 'tracking system'

Since 2006, the JRC and the *Istituto Zooprofilattico Sperimentale dell'Abruzzo e del Molise 'G. Caporale'* (IZS A&M) have been conducting a research project in which a prototype tracking system has been developed that demonstrate the feasibility of a system where a central community database receives information collected and transmitted by trucks in an independent transport fleet.

Hardware components of the prototype

The navigation system is designed to collect, record and transmit a defined set of data, as specified in the DG SANCO working document (18). Hardware components for the required functions, include the following:

- an onboard unit (Fig. 1) which has a:
  - general packet radio service (GPRS) engine allows the transmission of the acquired data to a remote receiver
  - global positioning system (GPS) engine acquires time stamped vehicle position data and is the system time reference
  - memory: used to store data internally to the onboard unit
- temperature sensors
- loading door sensors
- a cabin user interface that enables the driver to enter information equivalent to the journey log; furthermore, it informs the driver on the status of the system, including warnings.

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

The system is autonomous and operates in both the presence and absence of external power on the truck/trailer.

Hardware configuration overview

The system must be compatible with different types of long journey animal transport vehicles. To monitor the welfare situation of the transported animals when vehicles are uncoupled, the onboard unit is preferably

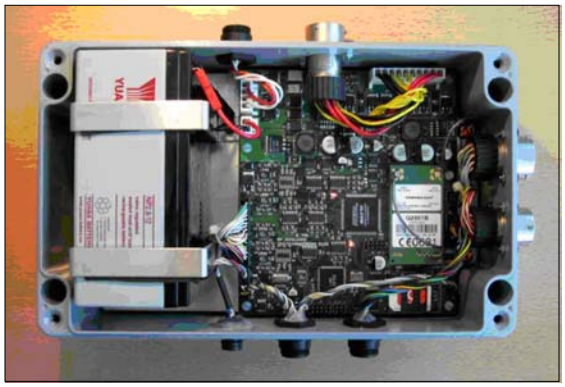


Figure 1
Onboard unit

installed in the animal compartments. A simplified overview for a system in a semi-trailer articulated to a tractor is shown in Figure 2.

Software components of the prototype: the community database

The onboard unit transmits data collected from the GPS receiver and from the truck sensors to the central database via the GPRS module and a Web-service is provided by the central database. The stored data are sent to a remote database at regular intervals (60 min, at present) and/or when certain events occur. Examples of these asynchronous events are high or low temperature, open or closed status of loading doors, tamper or malfunctioning event). The Web-service checks and stores the received data in an Oracle® relational database management system (RDBMS); each data block is distinguished by a journey identification, data block identifier and name and authorisation of transporters (Fig. 3).

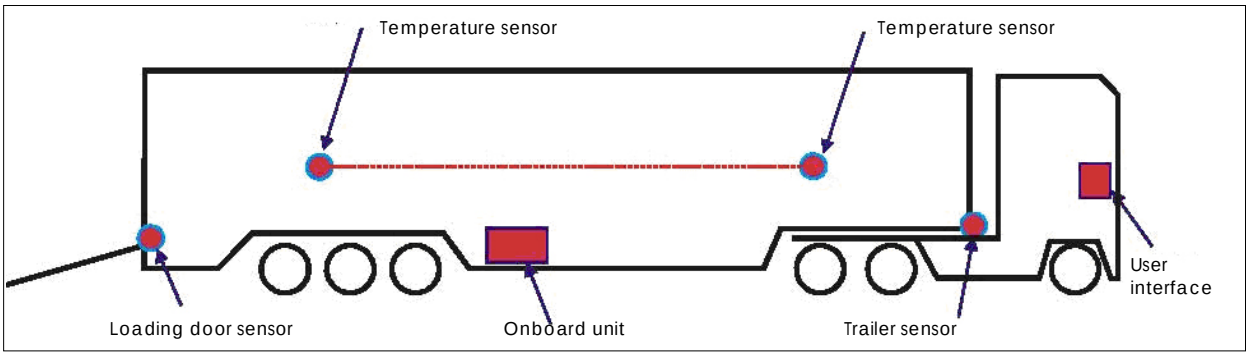
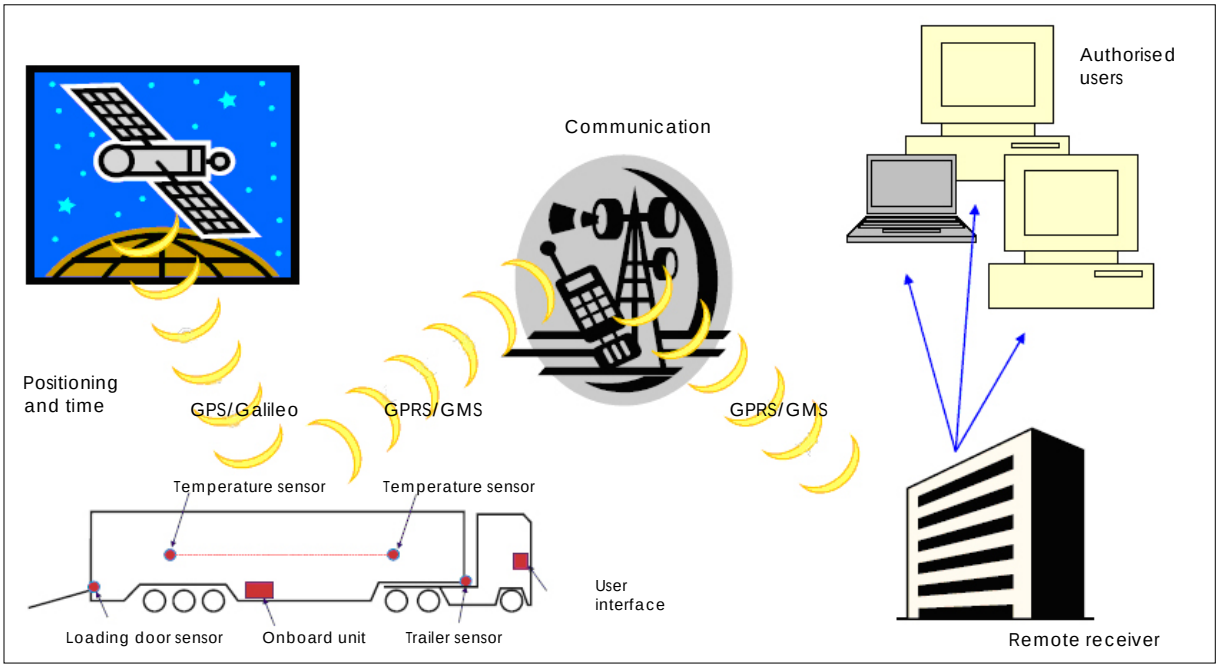


Figure 2
Installation of the onboard unit in the navigation system on a semi-trailer



GPS global positioning system
GPRS general packet radio service
GMS global management system

Figure 3
Technical architecture and data transmission system

The alphanumeric data thus transmitted is geographically positioned and analysed in real time via the Web using a GIS application. The central database uses an Oracle® RDBMS (48) within the Italian animal identification and registration system database (BDN: *banca dati nazionale*) and the GIS website uses an interoperability system between the BDN and the Google Maps framework (24).

Data are restricted to authorised users in the following way. A transport company can visualise data related to the trucks in its fleet. An authorised organisation of a member state can see the data related to trucks passing through the territory of the state. The administrator can access all data.

Readily available and up-to-date information is accessed in a visual and intuitive way by means of a user-friendly tool. In this way, the decision process can be faster, more efficient and targeted to the spatial area of interest. The application provides functions for the analysis of GIS data that can be filtered by date, truck, transport company and state, as shown in Figure 4.

Data can also be visualised using Google Maps (Fig. 5) to show the path of a journey, the position of the truck while in motion, when stationary, indicating whether the loading door of the truck is open or closed and showing anomalies of any nature, e.g. an open loading door when a truck is in motion.

Conclusions

Quality management measures can considerably enhance animal welfare in the road transportation of livestock. Adequate training of personnel to improve animal handling and other activities related to transport is a basic requirement. Real time technologies should be among the management tools used to monitor animal welfare on a transport vehicle. Behavioural and environmental measurement and recording can be of enormous assistance to drivers and provide an efficient method to manage the conduct of staff. Although some data cannot be represented numerically, behavioural and environmental measurements can be used in a risk analysis to minimise poor

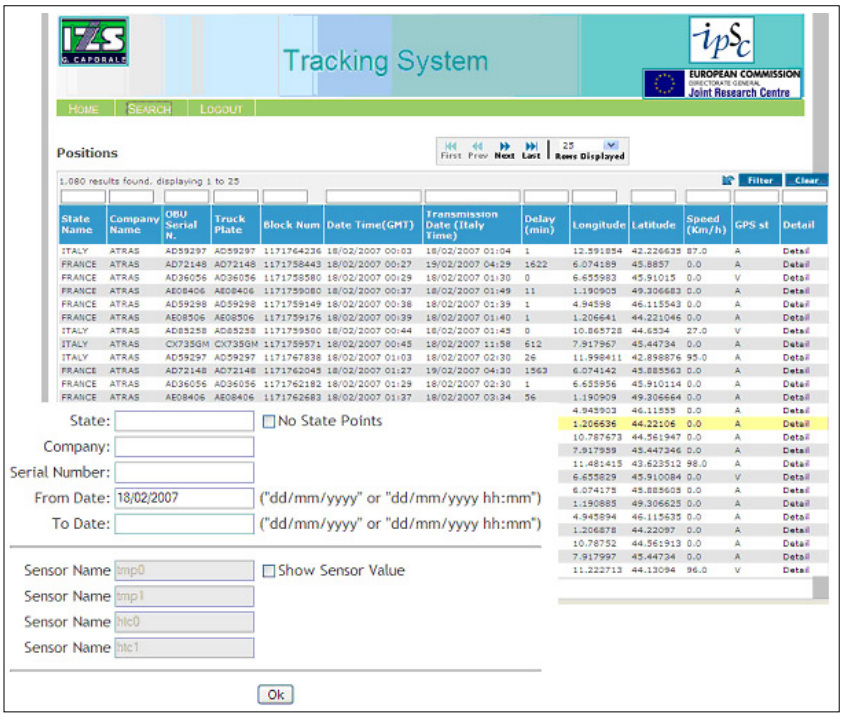


Figure 4
The filtering of geographic information system position data within the tracking system

Figure 5
Graphic presentation and analysis of geographic information system position data in Google Maps

welfare during animal transportation. New methods can be investigated to introduce objective behavioural data into risk analysis. Further studies should be performed to investigate the significance of some environmental parameters during transport, such as forces of motion, humidity and air velocity. Research projects, such as that conducted by the JRC and IZS A&M), could further improve real time monitoring systems, thus enabling competent authorities to perform more targeted, effective and efficient controls during animal transportation.

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