Real-time Internet-Based Traceability Unit for Mobile Payload Vehicles

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ABSTRACT

Today's agricultural machinery contain abundant technical equipment suited for capturing relevant data, but these data are seldom used because of difficulties in transferring such data from the machine to the management systems of the farm. In case of a smooth data transfer, the data could be used much more intelligently for real-time monitoring, management optimization, decision support and documentation. The idea presented here included collecting data in an automated way on the machine; hence no user interface was necessary. As an example, the collected data from a field machine could comprise GPS data creating a time and geostamp for every set of data acquired. By transmitting these data in real-time to an online database using GPRS, the farmer would be allowed to monitor the machine work from a webpage on his pc. To collect the data from the agricultural machine, the Siemens TC65 module comprising a small computer with a built in modem, was used. It is an off the shelf product, which significantly affects the price. The GPS hardware is any type of GPS that can deliver a NMEA 0183 GGA string via a RS-232-compatible serial port. This means that it is possible to choose the precision of the logged data. The proposed method of automatic data acquisition on field machinery has demonstrated that it is possible to analyse the machine efficiency index and a good compliance with theoretical models were shown. Another benefit of the system is the possibility to document the activities of the machines at given times. This could be used as documentation and traceability measures to comply with increasing legislative regulations in this area.

Keywords: Traceability, field efficiency, ISO 11783, data acquisition, controlled traffic

1. INTRODUCTION

The structural development and the imposed requirements on agriculture imply that innovative technology and knowledge are decisive for the future arable farmer (e.g. Sørensen *et al.*, 2005). Among others, the development is prompted by the invoking of EU regulation and actions plans (e.g. Environmental Technologies Action Plan, ETAP) as well as national environmental action plans increasingly marking the evolution of agriculture. In this regard, there is an urgent need for innovation and technological development, which may maximize the utilization of resources while at the same time maintain a sustainable development. The social importance of such a strategic development is significant as it may lay the ground for added value and jobs in adjacent businesses and other parts of the food sector.

A preliminary step in this direction is a renewed focus on the usage of advanced ICT systems and automation in agriculture (e.g. Suomi *et al.*, 2006; Nurrka *et al.*, 2007). Today's agricultural machinery contain abundant technical equipment suited for capturing relevant data, but these data are seldom used because of difficulties in transferring such data from the machine to the management systems of the farm (see figure.1).

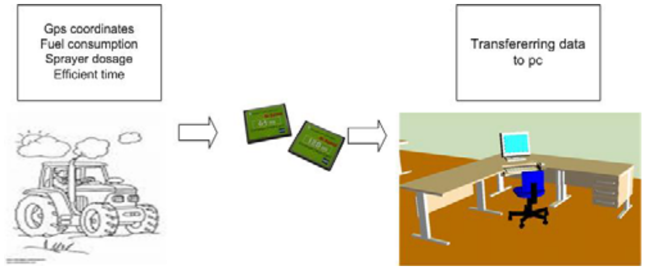

Figure 1: Typical data flow

Non-automated data flows incur the risk of data loss, data imprecision and incomplete data structures, which may compromise the use of the data (*e.g*. Hicks & Turner). Furthermore, the lack of simultaneousness as regard operation event and data acquisition and transferral reduce the application of the data in real-time monitoring and decision making. In the light of these impediments, more automated data acquisition systems are required.

In case of a smooth data transfer, the data could be used much more intelligently for real-time monitoring, management optimization, decision support and documentation (e.g. Opera, 2002; Pesonen et al., 2007). Especially, this is the case for agricultural fleet management, which can be seen as a farmers' or machine contractors' optimised decision making concerning e.g. resource allocation, scheduling, routing, real time monitoring of vehicles and materials and timely conducting field operations or customer orders. Automated data acquisition combined with suitable decision support systems can help advancing decisions and streamlining the whole process.

It may be expected that fleet management systems will display most benefits in connection with farm operations involving both in-field operations and transport operations. A typical operation of this type is the handling, transport and distribution of slurry. Yearly, Danish farmers transport around 27 mill. tons of slurry from the storage to the field, which equals 1 mill. loads of slurry and around 2 mill. km for transport. This indicates that an optimal organisation of the slurry transport in terms of minimised transport is essential. Close monitoring and operational analysis of the slurry transport and distribution as a way of improving the efficiency may be achieved by the use of automated data acquisition and fleet management systems.

2. MATERIAL AND METHODS

Two cases were chosen demonstrating the developed automated data acquisition system:

Case 1:

A developed autonomous plant nursing robot, Hortibot (Jørgensen *et al.*, 2006), uses the system for documentation of field operations. This is currently a passive data logging and documentation system.

Case 2:

A standard tractor with a slurry spreader uses the system as the basic unit for logging time, position and on/off spreading. In this case, the data were used as input for operations

analysis and comparison with normative operations models..

The idea presented included collecting data in an automated way on some designated machine, hence no user interface was necessary. As an example, the collected data from a field machine comprised GPS data creating a time and geostamp for every set of data acquired. Data was then transmitted, through the use of GSM/GPRS terminal (Siemens, 2006), in real-time to an online database using GPRS. It is worth to notice, that the transmission of data is in compliance with ISO 11783 (ISO-Bus). The farmer will now be able to monitor the machine work from a webpage on his pc (see Figure 2).

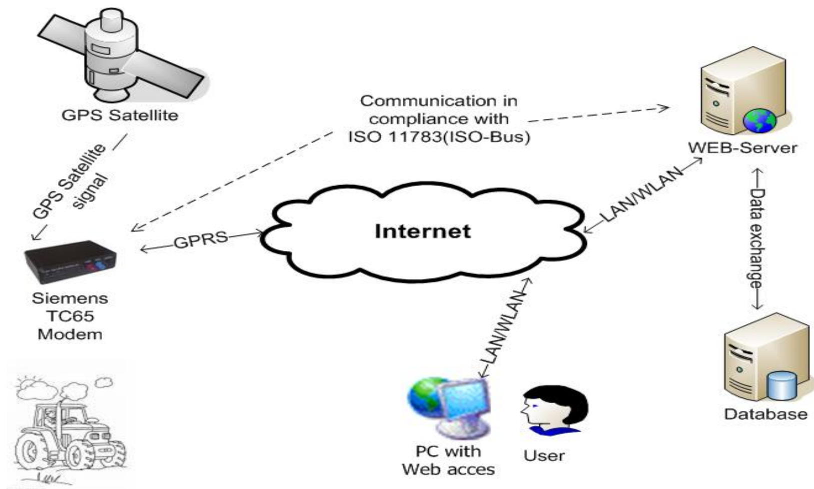

Figure 2: Automated dataflow

The above setup has several advantages:

- all field operations documented
- data security (Security log implemented)
- access data anywhere with an online computer
- access for anyone with permission for using the data

The software running on the Siemens module has a built in safety log, which means that even though there is no GSM network connection, data is stored internally and sent when connection is once again restored. The mobile unit chosen for these experiments was the Siemens TC65 platform which has the following main characteristics (for more detailed description see link under references):

- quad-Band
- GPRS Class 12
- JAVA IMP-NG
- powerful processor (ARM© Core, Blackfin© DSP)
- large memory profile (400 kb ram, 1,7 mb flash)
- TCP/IP connectivity
- interface rich (USB, RS232, I2C, SPI and more

The Siemens TC65 is a small powerful computer with a built in modem. It contains a lot of I/O options which makes it very versatile, and being an off the shell product, quite inexpensive also.

Concerning the GPS hardware, the Holux GR-213 was used, again a very reasonable priced GPS unit. The GPS hardware could actually be any type of GPS that can deliver a NMEA 0183 GGA string via a RS-232-compatible serial port. This means that it is possible to choose the precision of the logged data, by changing GPS unit.

The case study involving slurry transport and application was designed based on the activities of machine contractors. A test design was set up comprising operating slurry applicators using the methods of injection.

The evaluation and prediction of agricultural machinery performance are important aspects of all machinery management efforts (Sørensen & Nilesen, 2005). By specifying and quantifying the operations performance of farm machinery it is possible to select and plan the use of equipment in any given environment. The specific driving pattern that a farmers follows in order to cover a particular field has a significant influence on the efficiency with which, for example, time are consumed. By monitoring the driving paths using a precise GPS positioning system to record the co-ordinates of, for example, the slurry tankers as they cover the relevant field areas it is possible analyse and decompose the operations.

The field efficiency factor of machinery operations depicts the overall rate of work to a theoretical spot rate of work:

$$E = \frac{\text{Re}\,alised\ capacity}{Theoretical\ capacity} = \frac{t_p}{\left[t_p + \sum_{i=1}^{n} t_i\right]}$$

Where tp is the time elements allocated to actual productive work (e.g. emptying the slurry tanker) and ti is the various time elements allocated to work interruptions, auxiliary tasks, etc. The variation of the value of E is caused by a number of factors, e.g. as given below:

- the theoretical capacity
- the size and shape of the field
- the operation pattern
- the manoeuvrability of the machine
- the skill and experience of the operator
- soil conditions

By analysing the driving pattern and specifics of the field efficiency, irregularities and inefficient execution of work operations can be detected and corrected for future operations.

3. RESULTS AND DISCUSSION

Case 1:

The system developed is as described earlier and used for passive logging here. It can be set up to log system variables along with the GPS, and sent in real time. Trails of the plant nursing robot can then be viewed later or used as documentation for executed jobs. Especially the documentation part is important, as robots become more intelligent and carry out planned jobs autonomously. More information on the plant nursing robot Hortibot can be found at **www.hortibot.com**.

Case 2:

In this case, the T65 terminal was mounted on a self-propelled slurry injector and the whole process was constrained to the in-field part of the operation. The full data logging and driving pattern of the slurry application units are shown in Figure 3.

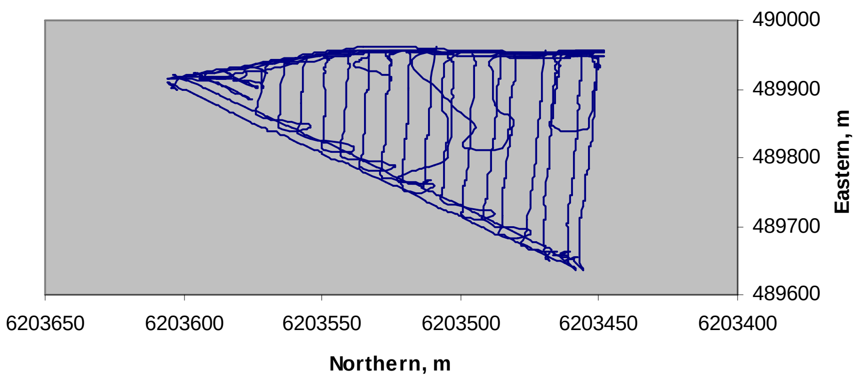

Figure 3. Positioning monitoring for slurry alication in UTM units

As a supplement to the GPS and transmitting unit, the spreading unit was mounted with an automatic switch for the indication of active slurry injection or not. The received data included position and time data from the mobile unit together with the indication of whether the switch was off or on. The logging interval was 5-6 sec. It was possible to calculate operational times and operational or work rates for the machinery, including the total operation of applying slurry on the field. The registered data and processed data together with model comparisons are shown in Table 1.

Table 1. Parameters from automated process acquisition

Date	*Start time*	*End time*	*Field*	*Tractor*	*Implement*	*Operation*
2006.05.15	09:21	10.44	X1	TerraGator	Injector	Slurry application

Time consumption in field				
Total[%]	*Spreading*	*turning, etc*[#.]	*idle*	*h/ha*
0.59 h	79 %	15 %	6 %	0.22

Driven distance in the field			
total	*working*	*turning, etc.*	*Distance km / ha*
4.89 km	66 %	34 %	1.81

Working speed			
over all mean	*all std*	*working*	*empty driving*
11.29 km / h	4.93 km / h	10.96 km / h	12.51 km / h

Model estimations

Time consumption in the field				
total	*spreading*	*turning, etc.*	*idle*	*h / ha*
0.66 h	69 %	23 %	8 %	0.24

Driving distance in the field			
total	*spreading*	*turning, etc.*	*distance / ha*
3.87 km	85 %	15 %	1.40 km / ha

It is seen that there are differences between the actual registrations and the normalised model estimations. Especially, it is noticed that the driven in-field distance differs significantly with the actual registrations somewhat higher that the prescribed modelled distances. Despite of that, the in-field time consumption is below the prescribed time requirements indicating that the vehicle have reached considerable higher velocities during, for example, driving with an empty tank. The maximum momentary recorded velocity was 25-30 km/h, while previous investigations have indicated an in-field transport velocity of 15-20 km/h (Sørensen, 2003). Also, these previous recordings indicate an idle time of 9 %.

4. CONCLUSIONS

The proposed method of automatic data acquisition on field machinery has demonstrated that it is possible to acquire operational data from mobile working units and subsequently, use these data to analyze and evaluate designated machine efficiencies. Also, targeted case analysis showed good compliance with theoretical models and estimations.

A specific benefit of the system is the possibility to document the activities of the machines at given times. This could be used as documentation and traceability measures to comply with increasing legislative regulations in this area.

Regardless of what automatic data acqisition systems and fleet management systems will be launched in the future, the following must be fulfilled:

- a demonstrated and positive cost-benefit analysis
- a clear flexibility in relation to specific applications of the system
- a simple user interface requiring no heavy learning efforts
- data logging and data storage is automatic and requires a minimum of human interaction
- integrations options with other internal management tools

5. REFERENCES

Hicks, C.R.; K.V. Turner, *Fundamental Concepts in the Design of Experiments*, 5th edition, Oxford University Press, ISBN: 0195122739, 1999.

Jørgensen, R.N., C.G. Sørensen, J.M. Pedersen, I. Havn, H.J. Olsen and H.T. Søgaard 2006. HORTIBOT: A System Design of a Robotic Tool Carrier for High-Tech Plant Nursing Automation Technology for Off-road Equipment 2006. Proceedings of the 1-2 September 2006 International Conference, Bonn, Germany

Nurkka, P., Norros, L., & Pesonen, L., 2007. Improving usability of and user acceptance of ICT systems in farming. Paper presented at the EFITA/WCCA Joint Congress in IT in Agriculture, Glasgow.

Opara, L. "Engineering and Technical Outlook on Traceability of Agricultural Production and Products". Agricultural Engineering International: the CIGR Journal of Scientific Research and Development. Invited Overview Paper. Vol. IV. December, 2002.

Pesonen, L., Kaivosoja, J., Virolainen, V., Oittinen, J., Kivipelto, J. 2007. "Remote Assisted Task Management for ISOBUS Equipped Tractor-Implement Combination". Agricultural Engineering International: the CIGR Ejournal. Manuscript ATOE 07 011. Vol. IX. July, 2007.

Siemens, 2006. WIRELESS MODULE TC65 – The M2M application platform. Siemens AG 2006. www. siemens.com/wm

Sørensen, C.G. 2003. C. Sorensen. “A Model of field Machinery Capability and Logistics: the Case of Manure Application”. Agricultural Engineering International: the CIGR Journal of Scientific Research and Development. Manuscript PM 03 004. Vol. V. October 2003.

Sørensen, C.G., N.A. Madsen AND B.H. Jacobsen 2005. Organic Farming Scenarios: Operational Analysis and Costs of Implementing Innovative Technologies. Biosystems Engineering, 91(2), 127-137

Sørensen, C.G.; V. Nielsen 2005. Operational Analyses and Model Comparison of Machinery Systems for Reduced Tillage. Biosystems Engineering, 92(2), 143-155

Suomi, P.; T. Oksanen; L. Pesonen; J. Kaivosoja; H. Haapala; A. Visala 2006. Intelligent functions for crop production automation. Proc. Of XVI CIGR World Congress 2006, Bonn