Title:

Automatie proeess data aequisition with GPS and LBS

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Summary:

The integration of Information Technology into farm mechanisation opens a high number of possibilities of monitoring and control. In tractor implement combinations using GI’S automatie data acquisition can be realised if all used equipment can be automatically electronically identified. Data collection can be guaranteed by a standardised electronic communication.

To reach this aim a "LBS open source library" was developed. It delivers all needed software components in a hardware independent way. With this library the agricultural equipment manufacturer are able to easily and fast develop standard conform systems following their specific requirements. The implement indicator IMI makes the identification of implements and the integration of specific sensors possible. A working system was developed in aLBS test environment and tested during on farm use. The system fulfilled all defined requirements and can be extended in many ways.
Automatie process data acquisition with GPS and LBS

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1. Aims of the investigation:
Information technology becomes more and more part of agricultural mechanisation. Within the past 15 years it's use is more or less limited to process monitoring and machine control for application work (spraying, spreading). With the introduction of the Global Positioning System GPS georeferenced data acquisition - "field scouting" - became a new field and machine control was updated to site specific fertiliser application. Unnoticed remained the possibilities of automatic process data acquisition and documentation, although with GPS the references "location" and "time" are available every time and everywhere.

Automatie process data acquisition could:

- improve the information content and the value of field records by getting complete and exact data sets
- record, assess and balancing the work of contractors and machinery rings by the real and specific expenditure instead of using flat rates by field sizes
- gain real data for administration purposes and support the increasing duty of documentation for EC regulations.

All these possibilities require the integration of this technology into all tractors and machines of a farm. In detail it is necessary to

→ use unambiguous, but for every farm free to define implement identifications

→ guarantee the free exchange of all machines between the different tractors on a single farm as well as on different farms

→ make end user specified adaptations possible regarding different requirements on quantity and quality of the acquired data

→ realise data analysis under "real time" and "post processing" conditions

2. Methods:
The realisation of these aims is reached by using the Global Positioning System GPS in combination with the already available electronic communication standard in the "Landwirtschaftlichen BUS-System" (agricultural bus system) by DIN 9684/2-5 and a specially developed "Implement Indicator" IMI®.
2.1 Global Positioning System GPS
Since the Global Positioning System NAVSTAR-GPS reached the status FOC (Full Operational Capability) on June 17th 1995 for everybody a standardised positioning and time service is available world wide free of any expenses. This service can be used with a high number of different receiver types. The time service following UTC is highly exact. However the measured positions show some errors. While switching off of SA (Selective Availability) on May 2nd 2000 (Clinton, 2000) the errors are in a range between ±5 to ±10m and fulfil most requirements of the automated data acquisition. Only in some special cases a higher accuracy and therefore dGPS is needed.

2.2 Landwirtschaftliches BUS-System (Agricultural BUS-System) LBS
For the electronic communication in mobile agricultural equipment with integrated data transfer to the farm management a working group of LAV (Landtechnik Vereinigung, Agricultural Equipment Manufacturers Association) developed and published (Auernhammer, 1989) a first standard between 1987 and 1997 (fig. 1).

It is based on the "Controller Area Network (CAN)" by BOSCH (BOSCH, 1989) using the data protocol V2.0A (11 bit arbitration). The prioritised data messages allow the integration of a maximum of 15 nods in aLBS. Tractor and implements have their own ECUs (Electronic Control Unit). These ECUs contain beside the needed sensors and actors also the masks for the interaction with the driver/user. These masks are transferred to the terminal after the initialisation process and are managed there like a "virtual terminal" as desired or as required by the user. Data transfer and task management are following the ADIS protocol by ISO 11787 (ISO, 1995).
2.3 Implement Indicator IMI
For a complete automated data acquisition it must be possible to clearly identify all machines and implements included in a tractor-implement combination. This is defined in LBS only for electronic systems in tractor-implement combinations using „full“ job controllers with sensors and actors.

A high number of machines used in tractor-implement combinations has no electronics and will never need one (e.g. a furrow press or a roller). To integrate these implements in an electronic communication an own identification unit is necessary. This unit can be realised following the rules of LBS on three ways (fig. 2):

1) **Implement Indicator integrated in BUS-connector**: The implement indicator is integrated in the LBS-connector housing. Therefore the moving BUS terminator is not needed because the BUS became less than 25 cm longer. The IMI becomes simpler and cheaper. It is fixed with a chain or steel rope to the implement and is therefore part of the implement. The integration of sensors is possible. It is realised with a cable to the sensor along the steel rope.

2) **Coupling Implement Indicator integrated in BUS connector**: Using implement combinations there is the need to build connector combinations. Again the BUS became less than 25 cm longer. And the special connector is also flexibly connected to the implement. To follow the mechanical requirements an additional miniaturisation of the IMI is necessary.

3) **Implement Indicator at the implement**: In transport or harvesting units the BUS has to be continued for additional BUS participants (e.g. second trailer). In such
cases the Implement Indicator is an additional element (with own housing) at the implement, has a moving termination and has an additional connector for the following BUS participant. It is easy to integrate different sensors to this IMI.

The IMIs designed in the above mentioned way contain the needed software for system initialisation and alive. The specific implement identification is also added by the IMI manufacturer. Changing this identification on the farm is possible by using the LBS terminal in a specific mode or via data link to the manufacturer.

If necessary IMIs can be equipped with specific sensors. In a plough with variable working width the adjusted working width will be detected. In transport units a simple detection of the situation loaded/not loaded can be realised using distance sensors between axle and frame or platform. Many other possibilities can also be realised.

3. Results:
The concept of the automatic process data acquisition system was realised in two following steps:

3.1 Open source library for LBS
Until now the realisation of LBS in Germany succeeded very hesitating and could not create a real standard conform and manufacturer independent system although a lot of efforts have been made. Following reason can be identified:

1) The agricultural equipment manufacturers still work and think "mechanical". In many cases they have not realised the value of electronics. Specialist for electronic development and electronic integration to the machines are often not available.

2) LBS as a standard is very complex. Although there have been research projects parallel to the standard development the definitions are not unequivocal in every case.

3) A standard is no regulation. The text can interpreted in different ways or the rooms within the definitions can be occupied "company specific".

4) The agricultural equipment manufacturers think and act as competitors. They form alliances and with the help of this alliances they try to separate from competitors. The standard is modified in a company specific way or is realised only rudimentary.

It seems that, because of this reasons, a real progress can only be gained if the necessary software for LBS is developed and published as a full library by a central institution and together with the industry is then tested and modified. Using that open source library the equipment manufacturers can then realise specific solutions with only little (software) educational efforts. These solutions will be:

- standard conform
follow the actual software

fulfil the implement specific requirements in the best way.

The developed open source LBS-library has a modular structure (fig. 3).

Figure 3: Open source library for LBS.

The library offers the most important LBS-performances and separates strictly between hardware-dependent and hardware-independent components. This way the application layer can be used unchanged on all platforms. Because all actions of a system, all interactions with other members and all CAN telegram formatting are implemented identically, all communication errors are avoided. Beside this the needed adaptations are restricted to a small part of the software.

3.2 Development and test of the System

Based on the beta-version of the open source LBS library a running test application could be developed in a short time. Therefore a system consisting of a tractor job controller, a virtual terminal, an IMI and system test facility was installed in the lab (fig. 4).

This LBS-development system is used to test all parts of the library. The tests are concentrated on the long term stable function of the whole system, on address conflicts, process data interactions and virtual terminal communication.

The IMI developed with the above mentioned tools was afterwards tested in areal LBS environment. System initialisation was done without any problems. During a test ride data defined in a task file were collected in a specified frequency and stored on a smart
eard. Data analysis was made in post processing and shows beside the driven way the registered total time and all part times. In addition georefereneed process data on drawing forces or applied materials could be registered (fig. 5).

Figure 4: LBS-development system for simulation and test.

Process data acquisition

Farmstead: power on - form boundary (x,y)
Field road: not form oreo on not field
Field: inside field with virtual headlond (time, consumption, ...)
  - total process
  - main field oreo
  - headlond oreo
  - virtual headlond oreo
Total: Farmstead + field road + field

Figure 5: Results of automatic data acquisition with GPS, LBS and IM!.
4. Conclusions:
A more efficient farm management requires more and better data. They can be delivered by using electronics in agriculture if it is possible to

- integrate position and time into data strings
- make a continuing data transfer possible by using a standardised communication system
- identify all participants in a tractor implement combination sure and beyond all doubts
- collect all needed information by specific sensors.

With the developed LBS library for the first time a manufacturer independent and at the same time standard conforable communication software could be implemented in an open source environment. It allows the easy and by the same time manufacturer specific integration of electronic process control in agriculture.

The developed conception for the implement indicator IMI completes the LBS. An extension of the test version with variable designed measurement programs could nearly fulfil all requirements of a farm or contractor or machinery ring specific automatic data acquisition.

5. References:


DIN 9684 (1997 - (999) : Schnittstellen zur Signalübertragung
Teil 1: Punkt-zu-Punkt-Verbindung (DIN 9684-1; 1997-02)
Teil 2: Serieller Daten-BUS (DIN 9684-2; 1998-01)
Teil 3: Systemfunktionen, Identitier (DIN 9684-3; 1997-07)
Teil 4: Benutzerstation (DIN 9684-4; 1998-12)
Teil 5: Datenübertragung zum Management-Informations-System, Auftragsbearbeitung (DIN 9684-5; 1999-05)
Berlin: Beuth Verlag
ISO (under development and partly published): Tractors, machinery for agriculture and forestry - Serial control and communication data network

Part 1: General standard for mobile data communication
Part 2: Physical layer
Part 3: Data link layer
Part 4: Network layer
Part 5: Network management
Part 6: Virtual terminal
Part 7: Basic application layer
Part 8: Power train
Part 9: Tractor ECU
Part 10: Process data application layer
Part 11: Task controller and management information system data interchange


ISO (1995): Machinery for agriculture and forestry - Data interchange between management computer and process computers - Data interchange syntax Geneve, ISO 11787

Spangler, A.: Open source LBS library.
http://ikb.weihenstephan.de/???

http://bioen.okstate.edu/home/mstone/asae99/