Hermann Auernhammer, Freising-Weihenstephan

Precise Agriculture thanks to Electronics

Nowadays electronics is essential for many agricultural machines and implements. These systems enable communication between various assembly groups in tractors and self-propelled machines, between tractors and mounted implements, as well as between various implements. By using a broad range of sensors, electronics is able to detect changing working conditions to optimally utilise resources with the highest possible yields and the best possible environmental protection.

Prof. Dr. Hermann Auernhammer is provisional head of the chair of Agricultural Engineering at the Technical University Munich, Am Staudengarten 2, 85354 Freising; e-mail: *hermann.auernhammer@wzw.tum.de*

Keywords

Electronics, communication, control, standardisation, precision farming

Literature

Literature references can be called up under LT 06412 via internet http://www.landwirtschaftsverlag.com/landtech/local/literatur.htm.

Electronics has become an essential part in all agricultural machines and implements. There, electronics earns completely different valuations and ratings. On the one hand, the farmer expects highest reliability combined with simple handling and takes the new possibilities for granted, once it works. On the other hand, he becomes helpless if the interfaces between the machines do not work together. Desperation arises with unexpected problems. After that, electronics becomes an unknown creature and is the 'evildoer' par excellence. Often, many people wish back the mechanical age, although the already attained and demanded precision is only enabled by utilisation of electronics. Nevertheless, we are right at the beginning of the age of electronics in agriculture.

Electronics in Tractors – Guidance within centimetres

In 1978, the first product line of electronic equipment for agricultural tractors, the „electronic hitch control" (EHR) was started by BOSCH [1]. Already at the end of the year 1980, the EHR became standard equipment for nearly all tractors. Electronic control unit, force measurement bolts and hitch position sensor allowed far more operations accompanied by improved precision than the preceding mechanical control systems. The control at both sides on the rear of the tractor was possible just as the hydraulics control joystick in the armrest. This established – surely unintentionally – the basis for the 20 years later upcoming „headland management systems".

Then, the electronic revolution in transmission design began. The implementation of continuously variable transmissions was firstly possible in a simple and safe way [2], new selectable driving strategies relieved the driver hand in hand with improved overall performance.

The next technical innovation was the adoption of higher injection pressures in combustion engine fabrication. In „common rail injection systems" electronics control the point of time for injection as well as the quantity and therefore ensure minimised consumption at lowest emissions.

The combination of both followed – so far autarkic – electronic units, creating the engine-transmission-management-system. This enabled the operation of the combustion engine within its optimal consumption range, the optimisation of the driving speed due to the needs of implements and simultaneously reducing noise emissions.

Lately, electronics found its way into steering control due to guidance applications, based on satellite navigation systems (GPS). Visual guidance information eases the work on the fields without under- or overlapping. Today's high-level guidance systems allow automated vehicle guidance with errors less than 2 cm – so purely preciseness !

Electronics within Implements – Sights on Environmental Protection

The second line of electronics in agriculture was control equipment for sprayers, which

	Fertilisation Approach			
Yield potential	Standard	Mapping	Online	Online + Map.
N fertilisation [kg ha^{-1}]				
high	180	200	163	175
medium	180	180	193	180
low	180	160	204	146
overall area	*180*	*180*	*187*	*167*
Yields [dt ha^{-1}]				
high	101	97	99	102
medium	86	86	97	96
low	85	79	87	94
overall area	*91*	*87*	*94*	*97*
Grain-N-balance [kg N ha^{-1}]				
high	3,6	23,2	- 19,2	- 9,6
medium	48,2	48,2	26,5	10,5
low	45,2	40,4	60,5	- 8
overall area	*32,3*	*37,3*	*22,6*	*- 2,4*
Economic output (free N charges) [ha^{-1}]				
high	984	947	995	1014
medium	780	780	822	935
low	745	706	799	889
overall area	*849*	*804*	*902*	*944*

Table 1: Site-specific fertiliser application in ecological and economical consideration

started simultaneous with the development of the EHR. This equipment allowed measuring the real driving speed without slippage in order to improve the accuracy of chemical substance application [3]. Plus-minus control buttons firstly enabled the user to perform site-specific adjustments. Additionally and therefore very early, the interconnection with the office PC via chip card (RFID technology) was realised [4] and accepted by the farmer.

With a time lag of about 2 or 3 years, the available electronic control systems have been adopted for fertiliser distribution technology. Here too less use of resources combined with environmental protection has been the main concerns. Understandably that it was tried to use universal hardware and application specific software for both jobs to reduce the necessary investments.

Not until the end of the 1990 decade, the available and approved electronics was adopted to seeding technology. The reason can surely be found in missing information about the potentials of quantity- and depth control.

Self-propelled Machines – Unimaginable without Electronics

In self-propelled machines, the utilisation of electronics occurred very differently. This is caused by being a „closed" system, where the manufacturer is free of external influences (no implements mounted) and therefore able to realise own solutions without considering other manufacturers and at the most restrained by related product lines in-house. Furthermore, the requirements towards self-propelled technology are widely variable and do not allow common developments. At the utmost a similar centralised calibration and monitoring concept of these complex systems is noticeable.

In combine harvesters, there is no doubt about the fact that sensors for grain loss measurement at the sieve and at the shakers represent a milestone in use of electronics. The subsequent yield measurement systems were of superior relevance, as effectively being the first introduction of „Precision Farming" in practise. Today, in combination with GPS and a sensor for grain moisture measurement, these systems are standard equipment in all top models of each combine harvester manufacturer.

After and by utilising these first systems, the integration of machine monitoring systems with optimal pre-adjustments stored for different field crops followed. Another extension was the control of the overall system by flow-rate. With these systems, today's crop harvest operates at highest performance and efficiency, minimised losses and is largely documented.

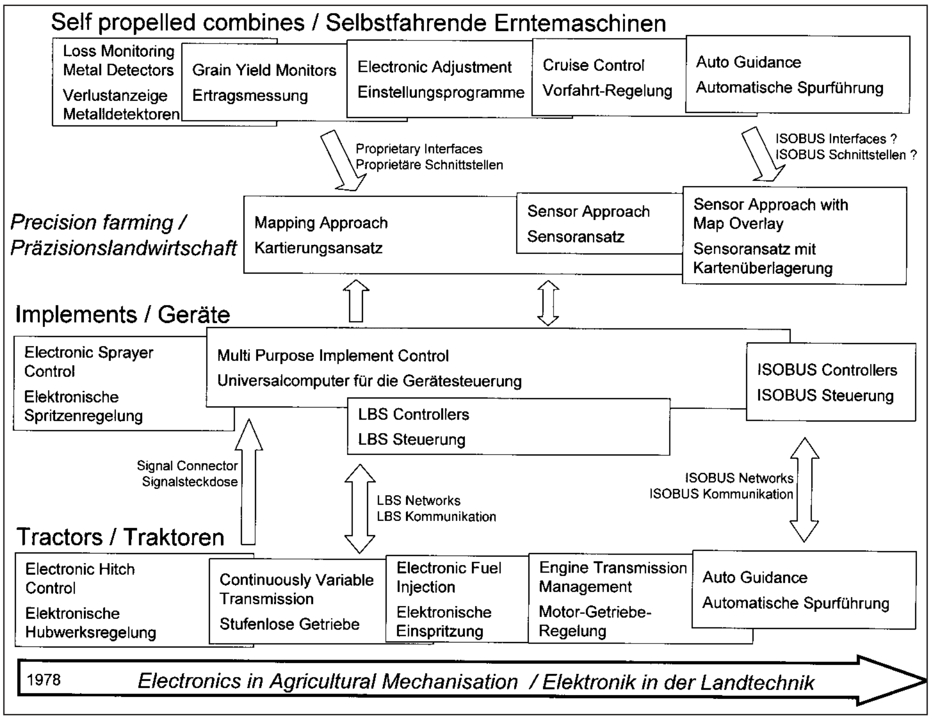

Fig. 1: Electronics and precision in agricultural engineering

Compared to this, the use of electronics in other self-propelled machines is right at the beginning. Electronic systems are presently used for centralised control and monitoring tasks and thus allow for a better load factor.

New are teleservice systems. They purse three fundamental goals:

1. Acquisition of essential machine parameters and their cyclic transmission to service centres.
2. Remote monitoring of machine parameters in addition with remote adjustment for performance optimisation.
3. The „real" teleservice by providing specific assistance at faults, and via centrally managed updates.

Standardised Electronic Communication

Electronics lives on and with information. Therefore, communication among electronic control units is a very essential and basic requirement for efficient overall systems.

Without pride, it can be stated that the standardisation of the „Agricultural Bus System" (LBS) due to DIN 9684 [5] was the „right action at the right moment." The agricultural engineering industry in Germany (and Europe) was put into position to

- integrate electronics within the systems right from the beginning,
- identify and improve system performance and capabilities,
- start working with these new systems and
- generally consider and realise the important connection of mobile electronics and the management system in the office.

The adoption of most of all parts of LBS within the succeeding international standard ISO 11783 [6] speaks for the outstanding achievements of the LBS standardisation group.

Regarding electronics in agriculture, the standardised electronic communication provided the missing link between electronics in tractors and electronics in implements.

Precision through the System for improved Economy and Ecology

In this respect, precision thanks to electronics in agriculture (*Fig. 1*) may and must be assessed within the system:

Today, yield mapping and the consideration of local heterogeneities within the application became reality via LBS/ISOBUS. The „Mapping Approach" allows the generation of specific local predictions, under the prerequisite that thereupon only one action takes place and the weather has only minor influence. In contrast, the pure „Sensor Approach" considers exclusively the growth within the vegetation and adds as much resources as necessary. This automates exactly the procedures, which were done manually or with the aid of plus-minus switching of the electronic control system by the farmer based on experience and expert knowledge.

In conclusion, the „Sensor Approach with Map-Overlay" opens up the combination of the vantages of both approaches and allows firstly a true „management upon heterogeneities." Besides pure economical advantages, this approach can much better meet ecological requirements, as ever before (*Tab. 1*).

Tomorrow, based upon today's available sensor technology, automated documentation of all processes becomes naturally. However, besides the universal possibilities of „Near Infrared Spectroscopy", it is necessary to integrate the likewise universal useable „Radio Frequency Identification (RFID)" into available systems. The consumers demand on all-embracing traceability then becomes reality.