



TECHNICAL AND TECHNOLOGICAL PARAMETERS OF ISOBUS SYSTEM SUPPORTED MACHINERY MANAGEMENT

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Abstract

ISO organization in early 90s defined an industry standard for the communication protocol among electronic devices of different manufacturers of agricultural machines. After that, all of the market actors recognised that this technology would be very important for agricultural electronics. The appearance of ISOBUS products in the market was in the mid-2000s. ISOBUS description could be found in ISO-11783. It is a very complex and large electronics protocol standard based on CAN and SAE-J1939 standards, extended for the Agricultural Industry. The standard consists of 14 different parts and more than thousands of specification pages.

Through the standards and the related technical background, the production processes and the operations could be followed and monitored by the extensive Data Management. Farmers' and users legitimate needs and developing goal is to elaborate a decision support systems that follow-up the utilisation of the machines and ensure the quality of operations. For this purpose, it is essential to determine which technical, economical, technological parameters, detection, measurement, transmission, processing, and evaluation becomes necessary.

In our work, we reviewed which mechanical characteristics, settings are monitored within the ISOBUS system by the major machine manufacturers. We developed the system of parameters and derived features that provide effective farm-, and land-management in case of attached equipment for spreading of input materials and tillage implements.

Keywords

ISOBUS, Data Management, Standardisation, agricultural mechanisation, product development

1. Introduction**1.1. Fast development of the electronics applications**

Similarly to other Industries, the agricultural industry saw a significant growth of electronics application starting from mid-late 80s. [9] Manufacturers with multiple development locations were also affected by the lack of a standardized protocol. In a fast growing environment the consolidation of product development organizations was not always a priority and therefore the presence of a robust industry standard was significantly supported by most of the industry players. Each team could easier concentrate on the development of the functionalities which could provide a competitive advantage. [8]

1.2. ISO11783 standard and the foundation of the AEF

After almost 20 years of application and development the ISOBUS (as defined in the standard ISO11783) has become a key element in the design of modern agricultural machinery. [5]

Even if the “plug and play” approach was the main concept inspiring the creation of the ISO11783 standard, there have been many factors which prevented a smooth and fast introduction of the ISOBUS products in the market:

- the complexity of the standard (more the 1,000 pages divided in 14 sections) [6]
- the rapid evolution of digital technology;
- the lifecycle of components of agricultural tractors and related return of investments;

The first two items mainly drove the creation of an industry consortium called AEF (Agricultural Electronics Foundation). This allowed manufacturers to create a common interpretation of the standard when applied to real products. [8]

Agricultural Industry Electronics Foundation, the AEF, was founded in October 2008 in Frankfurt at the VDMA. The founding members were 7 equipment manufacturers (John Deere, Grimme, Pöttinger, CNH, AGCO, Claas, Kverneland) and 2 associations (VDMA and AEM). AEF's aim was and is to provide resources and know-how for the increased use of electronics and electrical systems in mobile Farming Equipment. In the first years of its existence, it was clear that a succession of important tasks associated with ISO 11783 (ISOBUS) formed the main focus of AEF's work. [10]

Since its founding in 2008, the AEF has grown to a mature and independent Industry Foundation with over 200 members. [1]

1.3. ISOBUS Functionalities

For increased transparency towards the end-customers as well as to developers, the AEF has defined the so-called ISOBUS Functionalities that are now also the basis for the certification of ISOBUS products. The Functionalities encapsulate the different Control Functions on the ISOBUS network, such as the Terminal, the Tractor ECU, an Auxiliary device or a Task Controller. [10]

After a first period in which all the ISOBUS sections release levels were defined in a certain ISO11783 implementation level it become evident that a more practical approach was needed to address the increasingly complexity. Eight main functionalities, each of them with its set of ISO11783 sections release, were then released by AEF, covering the main functional aspects addressed by the standard (Figure 1).

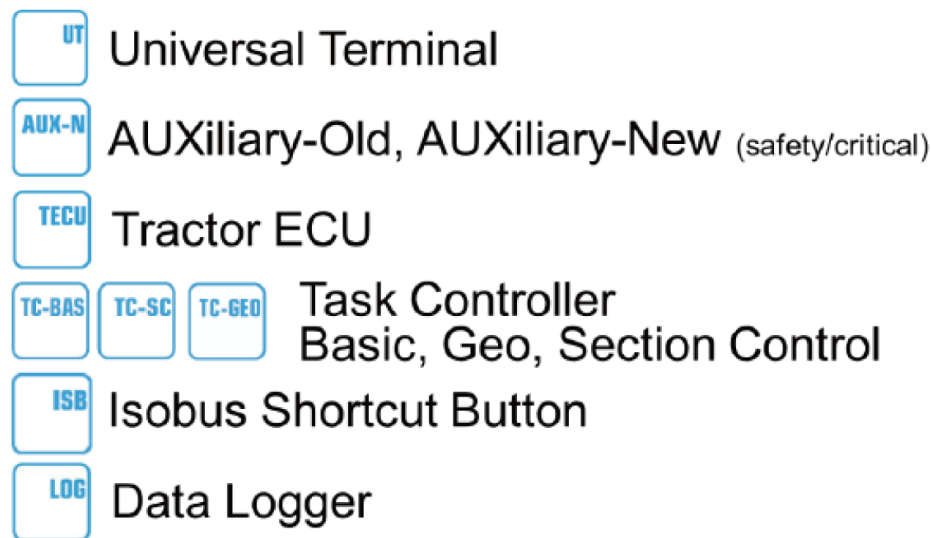


Figure 1. Today ISOBUS released functionalities [8]

The AEF has released the following Functionalities that can be certified today by the Conformance Test:

- UT – Universal Terminal. The capability of operating an implement with any terminal. The capability of using one terminal for operating different implements.
- AUX – Auxiliary Control. Additional control elements, such as a joystick, that facilitate the operation of complex equipment.
- TC-BAS – Task Controller - Basic. Describes the documentation of total values that are relevant for

the work performed. The implement provides the values. For the exchange of data between farm management system and Task Controller the ISO-XML data format is used.

- TC-GEO – Task Controller – GEO-based. Additional capability of acquiring location based data – or planning of location-based jobs, as for example by means of variable rate application maps.
- TS-SC – Task Controller – Section Control. Automatic switching of sections, as with a sprayer

or seeder, based on GPS position and desired degree of overlap.

- TECU – Tractor ECU. The tractor ECU is the tractor's interface to the ISOBUS. This provides information, such as speed, power take-off RPM, etc on the ISOBUS for use by the implement.
- ISB – ISOBUS Shortcut Button. A button present on a Terminal, or in the Tractor cabin, to be used to send a global message to all connected Control Functions on the ISOBUS to go to an Idle/Shortcut state. This Functionality is not to be seen as an emergency button! The Functionality approach is flexible, and new functionalities that come up in the future can easily be added once the Guidelines are defined and released. Functionalities that are currently under development are for example: TIM / ISOBUS Automation and the TC-LOG. [2]

2. Material and Method

2.1. Tractor Implement Management

Tractor Implement Management is one of the next steps in the near future. Within AEF manufactures are creating a robust way of opening automation to "trusted equipment" defining rules to clarify liability and guarantee a "plug and play" approach to the customers. [7]

2.2. Data Management

Data Management facilitates the exchange of data with the mobile equipment in the field. Through this functionality the user gets his data into a management system for registration purposes and further future planning. [3] Newly planned data can be generated by a decision support advisory systems and taken back into the farming equipment for planned field tasks and operations through for example a wireless service or telematics portal of the manufacturer.

2.3. Connectivity

The end-customers, i.e. the farmers and contractors, expect a seamless connectivity of implements and tractors, now and in the future. Also of all systems and data, both in the field on his machines as well as to other software and services. Seamless connectivity can only be reached by industry cooperation and by acceptance and implementation of Industry Standards for communication and data exchange. An 'open' mind to connectivity with competitors and suppliers of Farm Management Software solutions and other Decision Management services is therefore a must for all companies and equipment manufacturers. [10]

2.4. Future Directions

Future challenges in ISOBUS development are focused at three points:

1. COPL (Cost Optimized Physical Layer):
Cost optimization allowing a higher diffusion of the ISOBUS technology (also more suitable for smaller machines). The goal is to reach lower volumes and smaller application.
2. WIC (Wireless Infield Communication):
3. HIS (High Speed ISOBUS):
 - Distributed high-resolution position/correction signals.
 - Digital Video Systems.
 - Improved Service and Diagnosis (flash ECUs, Log-files, raw data streams for debugging).
 - Mobile Internet on ISOBUS for dedicated server/client requests.
 - High Voltage data Connection.

As technology evolves, manufacturers must take advantage of new opportunities with the end goal of providing farmers with a higher productive, higher quality and more efficient farming cycle. [4, 7]

3. Results

3.1. Overview of selected parameters for processing and monitoring of products of the market's leading agricultural machinery manufacturers

In first step of the research work the measured and processed parameters of most significant attached working equipment was defined. The sprayers, fertilizer spreaders and seed drills (including towed-, and attached version, and also the direct-, and mulch sowing machines) and the ploughs were selected.

For machines listed in the measurement and processing of the measured values of the following parameters were determined:

- a. Worked area
- b. Theoretical quantity
- c. Weighed quantity
- d. Applied quantity
- e. Time in working position
- f. Distance in working position
- g. Pump speed
- h. Spray pressure
- i. Hopper volume
- j. Current speed
- k. Speed source
- l. Operating hours - motor
- m. Current track width
- n. Motor torque in %
- o. Motor speed in rpm
- a. Average consumption AdBlue in l/ha

- b. Average consumption Diesel in l/ha
- c. Current blower fan speed
- d. Blower fan speed setpoint
- e. Minimum speed
- f. Maximum speed
- g. Target speed
- h. Spread rate actual value
- i. Spread rate setpoint
- j. Working position
- k. Setpoint in per cent
- l. Theoretical residual quantity
- m. Hopper content
- n. Working width

3.2. The determination of monitored technical-technological parameters during the works of tractor and attached working machine combination

The next phase of work was the definition of the technical-, and technological parameters which could be measured, processed and displayed during the works of tractor and attached working machine combination. These characteristics were classified into four main groups.

The groups are:

Quality of work	Power-, and capacity-utilisation	Work safety	Cost
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We denoted subgroups within the main groups, according to specificity, and the selected parameters were grouped in this way. The physical parameters which are the base of monitored technical and technological characteristics are presented in the Table 1 according to above illustrated classification.

To assure the quality of work it is important to ensure adequate working depth, tracking of the dispensed amount of input materials and analysis of energy consumption.

In terms of the power-, and capacity-utilisation the area, the time, and the quantity (by volume or weight) proves to be key factors.

The work safety can be provided by the in time detection of crash, injury or by detection of early signs of developing malfunctions e.g. the formation of irregular resonance, or limitation of overload, and the monitoring of drivers behaviour.

From the users part it is essential to take into account the cost. From this perspective the labour cost, the machine work cost, and the cost of inputs are most determinative and it is primary to follow-up them.

Conclusion and Recommendations

The technical solutions provided by the ISOBUS system – registering of the operating parameters of power machine and attached equipment – could review not only the technical and service characteristics of operation of each machine. There is an opportunity to overview the features on farm-management level that are the effective core devices for corporate governance, for efficient production and for successful planning too. These data in case of high-volume machine fleet, whether it is farm-fleet or contractors fleet, makes transparent the administration of machines and the performed tasks by their. These can be defined as the effective modules of the company's management systems.

From technical approach it is essential to ensure compatibility of ISOBUS communication between the products of different producers, between the power machine and attached implement, and on the level of telemetrical data transfer too. Mostly the European market of agricultural machines is the main market where the multi brand interconnectivity represents the biggest challenge. This innovative market is that where the ISOBUS has the widest application.

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Table 1. Recommended follow-up ISOBUS values

Quality of work	Power-, and capacity-utilisation	Work safety	Cost
Working depth <i>Measured value:</i> • traction, drawbar deformation, • slip, • pitching angle of tractor	Area <i>Measured value:</i> • trip length, • Current speed, • Average speed, • attached machine width, • adjusted working width staging), • Direction of operation (coordinates)	Crash, injury, resonance <i>Measured value:</i> • engine oil viscosity, • temperature, • soot content, • hydraulic oil viscosity, • hydraulic oil temperature, • tire pressure, • vibration	Labour <i>Measured value:</i> • Number of vehicle card
Dispensed amount of input material <i>Measured value:</i> • PTO speed, • pump flow, • seed hopper weight, • seed plates speed, • fertiliser hopper weight, spreading disc speed	Time <i>Measured value:</i> • shift time, • engine operating hours	Overload <i>Measured value:</i> • gear, • motor temperature, • 3 point hitch height (working depth), • drawbar deformation, • PTO deformation	Machine work <i>Measured value:</i> • Work operation code, • Work operation date, • duration of work operations, • correction factor of work operations
Energy consumption <i>Measured value:</i> • fuel quantity, • actual fuel consumption, • exhaust gas temperature, • number of fuel card, • quantity and time of refuelling	Volume or weight <i>Measured value:</i> • seed hopper weight, • seed plates speed, • fertiliser hopper weight, • spreading disc speed	Drivers behaviour <i>Measured value:</i> • cabin temperature, • time of using automated steering, • field map setting	Input material <i>Measured value:</i> • amount of spreaded input materials, • area, distance × working width • unit price of inputs, • duration of the service, • cost of service