The AEF - Ag Industry's initiative in electronic standards implementation

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1. Introduction

Implementation of complex electronic standards, such as for example ISO-11783, may lead to different interpretations and thus different implementations in the field with a non-compatible result between tractor and implement for the farmer or contractor. In the past decade, uncoordinated introduction in the field of such standards has proven to be sometimes problematic and undesirable, and therefore the Ag Industry recognized the need to cooperate in a new worldwide organization. This report describes the background and history leading to the founding of the AEF organization, and the actions taken by the industry to get a coordinated introduction of new standards and functionalities into the field with focus on existing standards, but also future focus for new upcoming technologies and standards.

2. Background and history

2.1. ISO-11783 history

The ISO-11783 standard, also commonly known as ISOBUS, is a complex piece of work consisting of 14 different parts and over 1000 pages of information ranging from the definition of the Physical Layer to the higher level of Application Layers such as the Universal Terminal or Task Control functionalities. The ISO started the first specification work in the early nineties through the so called Working Group 1 (ISO designated as: TC23/SC19/WG1). All the way through the nineties the standard was written and came to its definition with inputs from experts from many companies, universities and associations. The standard was based on the already existing SAE-J1939 standard, and the primary goal has always been to remain compatible to J1939 and align the activities with SAE. However the WG1 members defined the standard much further because of the different needs in Agriculture and added the additional layers and parts to the ISO-11783 standard. The main reason was that ISOBUS was to be used as an open system between the tractor and the implement where J1939 components were primarily used in closed systems like internal tractor bus systems or self-propelled equipment.

2.2. ISOBUS introduction

Around the end of the nineties some companies started with the first implementations of ISOBUS applications, mainly focusing on just the communication between tractor and implement and the usage of the Universal Terminal in the tractor. Since most tractor manufacturers by then still did not supply ISOBUS solutions or ISOBUS terminals, most of the early applications were retrofit solutions offered by either the implement manufacturers themselves together with the first ISOBUS implements, or by third party suppliers in the early years of ISOBUS, such as for example Müller Elektronik. Some of these early applications based on this standard were presented in November 2001 at an independent ISOBUS exhibit at the Agritechnica show in Hannover. At that show special attention and focus was on the interoperability and compatibility between manufacturers. The year 2001 appeared to be a breaking point for the acceptance of ISOBUS. Many manufacturers realized that an open and standard bus system was the only solution for the future to overcome the

many island solutions (example in **Figure 1**) for controlling implements and for communication between the tractor and the implement.

Another breaking point in the acceptance by the Ag Industry was the release of an existing patent from the mid-eighties by Kverneland Group on serial communication systems and CAN-bus between the tractor and the implement. By openly announcing and releasing the patent in order not to block any further ISOBUS developments, the future was now open for any manufacturer without potential blockages to start with ISOBUS and adopt it as the new standard in their companies.

2.3. ISOBUS growth

From 2001 on the ISOBUS standard grew to maturity and became the international standard that was adopted by the Ag Industry. Tens of thousands of ISOBUS implements, tractors and components were successfully sold worldwide, but despite this high number there were also 'incompatibility problems' to be solved. Farmers or contractors that purchased equipment based on this standard were often promised that the investment in ISOBUS was a secure investment and would give a "Plug and Play" solution for all the needs. However after a few years in practice this promise appeared to be much different. While the industry, together with DLG as the only ISOBUS test institute in the world, focused on the technical aspects for testing and certifying components, the practical implementations in the field appeared to be sometimes problematic leading to situations where the end-customer simply did not have a working solution between cross-branded equipment. The pillar of the open standard, multiple components and cross branding solutions that work together on an ISOBUS network, was suddenly under discussion in the market and end-customers started to lose confidence in all the made promises. Technically, and just on the component level, there was no problem. With the ISOBUS test developed and offered by the DLG, manufacturers were able to certify their components, and could prove that the components were complying with the standard. But due to the complexity of the standard, and often different interpretations of what functionalities (parts) of the standard were offered to the end-customer, sales and dealers often sold solutions as ISOBUS compatible, basically without knowing what is behind the functionality of a certain product. Apart from that, the Ag Industry used all kinds of different wording and naming towards the markets, such as for example "ISOBUS prepared", or "ISOBUS light", all misleading the end-customer.

2.4 Awareness

The state-of-the art system by then would comprise of a system typically as shown in **Figure 2**, and which is still as of today a realistic combination in the field. In this example, when the customer was promised to buy an ISOBUS compatible implement, the customer would expect it to work with all the installed components, including the auxiliary joystick. Now when the Implement ECU software does not support the Aux protocol in ISOBUS, the joystick in the tractor cabin would not work in combination with that implement, leading to a frustrated customer since he was promised and often sold a working ISOBUS solution. This kind of incompatibility was mainly due to lack of knowledge and a combined, aligned and structured approach towards the markets by the industry itself. Actually there was a missing involvement of all disciplines from within the companies; it should not only be driven by Engineering departments as it had been for more than a decade, but also by Marketing, Product Management and Service. The awareness that the realization of electronic standards in the Ag Industry can only succeed if the global acting players of the Ag Industry will accept and force them, had finally resulted in the situation that the Ag Industry recognized the need to join forces in October 2008 by establishing the Agricultural Industry

Electronics Foundation (AEF e.V.). Secondly the industry was depending on just one single certification test, and wanted to develop its own independent test that could be used by different Test Labs over the whole world according to standard procedures.

3. Ag Industry's initiative - AEF

AEF e.V. was founded in October 2008 in Frankfurt, Germany by 7 agricultural equipment manufacturers and 2 associations, and currently has more than 150 worldwide members. AEF is a 'verein' (association) under German Law, but acts worldwide as a global international organization which started to take over the role of many smaller distributed organizations and initiatives such as the Implement Group ISOBUS (IGI) in Europe (mainly Germany) and the NAIITF (North American ISOBUS Implementation Task Force) as well as some smaller initiatives that were coming up in other parts of the world. The AEF initiative has become the central, independent, international organization and platform which is accessible to all interested groups from the field of electronic systems in Agriculture. All activities are financed through the membership contribution of the core members and service charges from general members as well as licenses for tools sold to its members.

3.1. AEF's main objectives

- To define guidelines for the implementation of electronic standards in a structured and aligned way, in particular with first priority for ISOBUS.
- To coordinate technical improvements (ISOBUS) including management and enhancement of certification tests.
- To coordinate international cooperation in Ag Electronics technology.
- To establish and continue the international development and expansion of electronic technology as well as implementation of electronic standards.
- To build synergistic partnerships between Ag Equipment manufacturers for the benefit of end-customers.
- To organize certification support, training, workshops, marketing activities and consulting relating to any Ag Electronics international standards.

3.2. Organization and management

AEF is managed and steered by the core members in the so called Steering Committee. All Steering Committee members have equal voting rights, except for two supporting members that are provided by the VDMA and AEM. 'Day to day' business is managed by the Chair Group, which consists of an elected Chairman and Vice-Chairman, and a Treasurer and Secretary each provided by VDMA and AEM respectively. The development work is done in Project Teams which are managed by Project Team Leaders that report frequently in the Steering Committee meetings. Since there are currently nine Project Teams active, the organization chart was recently adapted to the latest organogram version as can be seen in **Figure 3**.

3.3. Project teams

- PT1 – Conformance Test. Scope: Development of state-of-the-art testing and certification processes.
- PT2 – Functional Safety. Scope: Address Functional Safety topics for all Project Teams. Develop Functional Safety guidelines.
- PT3 – Engineering & Implementation. Scope: Define implementation guidelines and draft recommended changes and additions towards ISO. PT3 supports all other Project Teams.
- PT4 – Service & Diagnostics. Scope: Development of the AEF Database showing the compatibility of certified components, as well as addressing unified standard diagnostics and support for this diagnostics in the database.
- PT5 – ISOBUS Automation. Scope: Define guidelines for Tractor-Implement Automation, TECU Class 3 and Sequence control. Define a secure protocol for authentication in order to use AEF certified components only.
- PT6 – Communication & Marketing. Scope: Communication and alignment of activities towards the International press, tradeshows and events. Promote and market the AEF Products such as the Conformance Test and the AEF Database.
- PT7 – High Voltage. Scope: Define and prepare guidelines for the new area of High Voltage systems in Ag Equipment which may be brought into ISO for further standardization.
- PT8 – Camera Systems. Scope: Define a guideline for a standardized camera connector, and future digital system for use of camera's on Ag Equipment.
- PT9 – FMIS. Scope: Develop common solutions for connecting mobile vehicles and attached machines to Farm Management Information Systems. Harmonize and expand existing standards for data exchange.

3.4. Tools and products

In the past years the following tools and products have been developed by the AEF:

- AEF Conformance Test. This test is used by AEF accredited Test Labs to certify ISOBUS components. The tool itself is also used by manufacturers to help supporting in development of ISOBUS software. A license per seat is needed to use this tool.
- AEF Database. An online tool that is accessible for all dealers and users worldwide to consult the compatibility of various machines and components of all the brands/manufacturers in the database. A company license is needed to use the AEF database.
- Plugfests (**Figure 6**). AEF organizes twice per year a so-called Plugfest, one in North America and one in Europe. Plugfests are events where developers of different manufacturers test their (mostly new) components against each other. Recent Plugfests were held at NTTL in Lincoln, Nebraska and at CCI/FH Osnabrück in Germany. The last Plugfest had a record breaking attendance of 200+ participants proving the increasing popularity of ISOBUS.

4. ISOBUS in functionalities

In order to solve the complexity of the ISOBUS standard as reported in Chapter 2, the AEF project teams defined so called Functionalities that encapsulate the different control functions in a network,

such as the Terminal, the Tractor ECU, an Auxiliary device or a Task Controller. For increased transparency, Functionalities have been defined. And by splitting up the standard into well predefined functions, it is more easy to explain to the end-user what it means when a device is said to be ISOBUS compatible. It does not necessarily mean it supports all functions, but by using the AEF Guidelines and Functionalities, a manufacturer can now clearly implement compatibility to other devices according to these specific functions.

An ISOBUS Functionality is a product which can be explained and sold to the end user as a separate "module" on the ISOBUS. One or more Functionalities can be bundled together into a product intended to interconnect with other products that contain AEF Functionalities. In an ISOBUS system only the least common denominator of Functionalities can be used. Only Functionalities supported by all components involved are available. And only then the famous "plug and play" will work. The AEF has defined the following Functionalities:

- 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 "job calculator". This provides information, such as speed, power take-off RPM, etc on the ISOBUS for use by the implement.

Future Functionalities that are under development are for example: ISOBUS Automation and ISB (ISOBUS Shortcut Button).

5. AEF Conformance test and certification

5.1. Conformance Test

In order to manage the whole process of certification of ISOBUS components, the AEF has developed a new, highly automated, AEF Conformance Test for its members and the AEF accredited Test Labs. The Conformance Test offers formal checking and testing of ISOBUS products by the Test Labs against the defined AEF Functionalities. Only when a product has passed the official AEF Conformance Test, the Test Labs are allowed to publish the AEF certified component into the AEF Database. The aim is a clearer description of the effectiveness of a manufacturer independent ISOBUS system and increased operational reliability for the farmer. The tool is also available for the development departments of AEF members, to enable continuous checking for compliance with the standard during the development phase of their own ISOBUS products.

5.2. Certification

This certification process is mandatory for all AEF members in order to make data for certified components available for the AEF database and for the general public. This is supported by the newly developed AEF certification label as shown in **Figure 4**. It confirms that the product tested complies with the ISOBUS standard and with the AEF Functionality Guidelines. The AEF certification label shows that the component successfully passed the AEF certification process. Six abbreviations in small squares symbolize functions, three squares with three dots each indicate that the system is open and expandable.

5.3. Accredited test labs

AEF has currently appointed four Test Labs that are allowed to carry out the formal certification process;

- REI – Reggio Emilia Innovazione (Reggio Emilia, Italy)
- TCI – Test Center ISOBUS (Osnabrück, Germany)
- NTTL – Nebraska Tractor Test Laboratory (Lincoln, Nebraska, USA)
- DLG – (Gross Umstadt, Germany)

The Test Labs will undergo an accreditation process as defined in ISO-17025. The process of accreditation is outsourced by AEF to Enama (Ente Nazionale per la Meccanizzazione Agricola; location Rome, Italy).

5.4. AEF database

Detailed information on the certified product can be found in the AEF database at www.aef-isobus-database.org. For the use of multiple components within the same ISOBUS system the functionality icons can be compared within the database to identify the lowest common denominator (**Figure 5**). Only Functionalities which are supported by all components involved can be used jointly. Manufacturers also added their legacy DLG tested components in the database, and these can still be used to check compatibility as well with newer AEF certified products. Only DLG tested components prior to 2013 will appear in the database.

Many questions are now answered through the AEF ISOBUS Database;

- Who is responsible if components do not work together: the manufacturer of the tractor or of the implement?
- How do I find a fully ISOBUS compatible implement for my ISOBUS tractor, in order to make use of the full Functionalities of the system?
- Is my existing implement perhaps ISOBUS certified and compatible with the new ISOBUS tractor to be purchased? And if so, what Functionalities can I use with the combination?

The database contains all relevant information on all ISOBUS certified machines and equipment. After selecting a combination of tractor and implements with a few mouse clicks, the user can see immediately if the selected combination is compatible and which Functionalities it is equipped with. Alternatives can also be compared with each other. If an implement cannot be found in the database, it is not AEF certified. The database helps dealers in advising their customers and also facilitates troubleshooting by the dealers or after sales service departments. This can significantly

reduce downtime. Also, the industry collects reports on problems in the database and this information remains available in the form of an ISOBUS knowledge base. It can also be used by the after sales service department for faster on-site diagnosis and troubleshooting. At the same time companies can use the database to simplify the processes for conformity tests and certifications. The database is updated continuously with the latest certifications by the manufacturers.

6. Future activities

New focus for the AEF is to align other standards such as Functional Safety of electronic control systems or Farm Management systems, and to prepare new developments in the area of standardization, such as:

- High Voltage;
- Camera Systems;
- Wireless Communications

7. Conclusions

The Ag Industry has successfully joined forces with the founding of AEF. With over more than 150 members worldwide, and very active Project Group communities, the organization has matured in the five years of its existence to the central platform for electronic standards implementation serving the whole Ag Industry. The realization of electronic standards in the Ag Industry has succeeded because the global acting players accepted and enforced them. Cooperation at a global level has proven to be an absolute necessity, and the AEF has grown to the international platform facilitating all this for its members.

Figure 1 - Many 'island' solutions to operate implements or perform other tasks

Figure 2 - Typical standard ISOBUS system

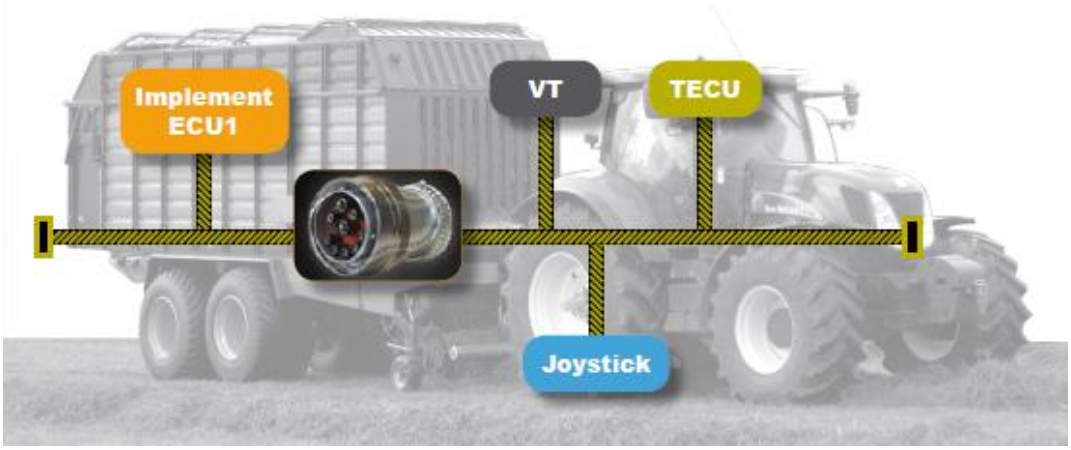

Figure 3 - AEF organisation

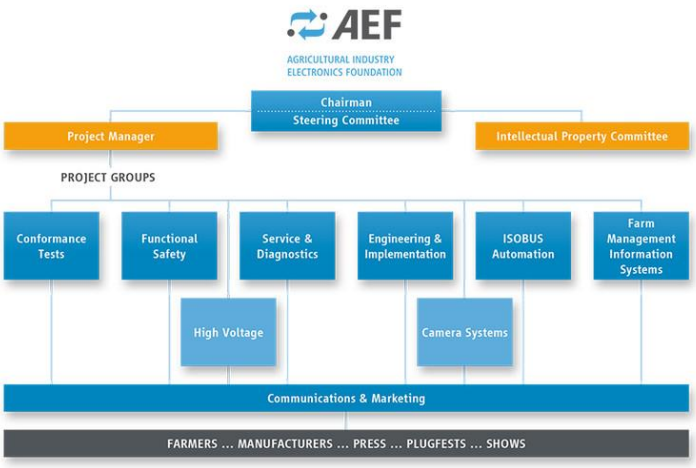

Figure 4 - AEF certified label

Figure 5 - AEF database compatibility check

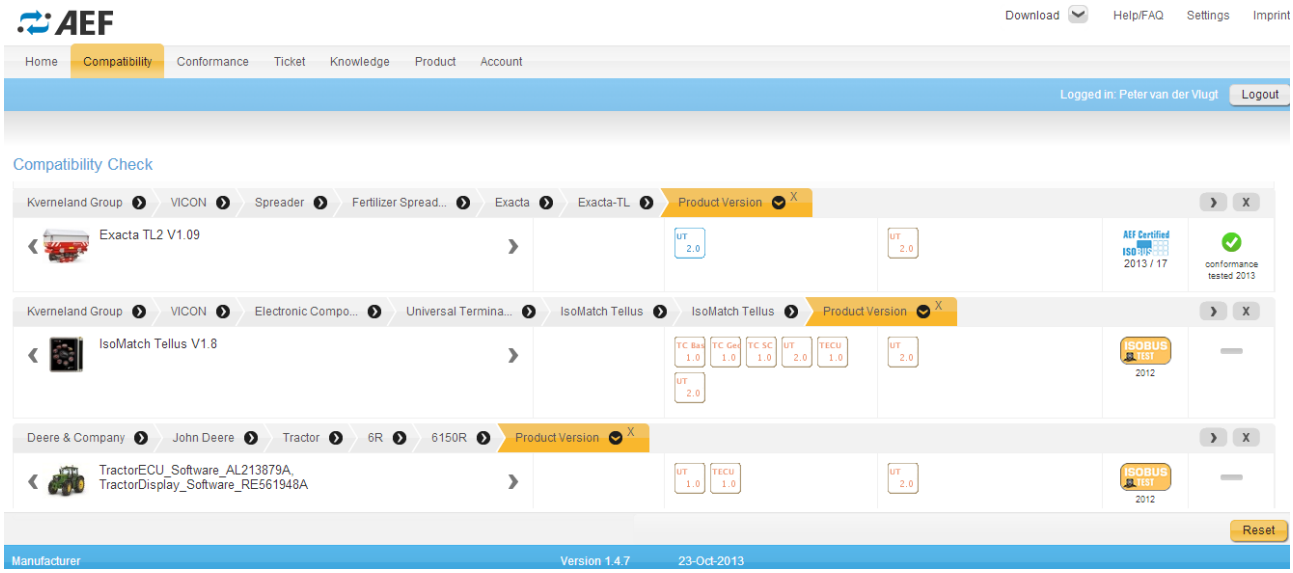

Figure 6 - Plugfests