Design and Analysis of ISO 11783 Task Controller's functionality in Server – Client ECU for Agricultural Vehicles

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Abstract. *A modern agricultural vehicle's electronic control units (ECU) communicated based on the ISO 11783 standards. The connection of different machines, implements, different manufacturers into a single bus for the exchange of control commands and sensor data are a challenge for the precision agriculture. One of main functionality is the Task controller in the intelligent monitoring system. The task controller is to log data and assign set-point values for automated work (task) sequences on the implement bus. It also serves as a gateway between the farm management information system (FMIS, as like Farmer PC) and the mobile implement system (MICS, as like implement ECUs). In this research work, we develop the task controller application program for server ECU (such as Virtual Terminal) and the client based on the OSB-Ag Company commercial libraries for ISOBUS. There have two main libraries for ECUs, which are the server-core-suite and the ISOBUS-stack. The server-core-suite have application program interface for the task controller (TC), virtual terminal (VT), and file server (FS). The TC application implemented by the Qt graphical user interface (GUI) tool at Linux based operation system. TC-Core enables processing of tasks for section control, variable rate technology and data logging. The TC is responsible for task management in conjunction with the FMIS, and recording machine-related data such as working time, working width and worked area. Also the TC application records operations in the field automatically – in simple cases this will be field-based but with precision farming it will be position related information by using GPS client. The client ECU side development is by using the IsoAgLib-SE (safety edition) library which is called ISOBUS-stack. In this research project implement the sprayer control units, its contain the vt, tc, tecu client functionality.*

Keywords. *ISOBUS, Task Controller, Implement ECU, GPS, Agricultural Vehicles*

Introduction

This paper describes the implementation of an agricultural machinery control is an interdisciplinary field of study concerning the integration of mechanics, electronics, and software engineering expertise. Today a new generation of tractors exists with capabilities so advanced they can be assumed in many of the roles and responsibilities once entrusted to their human counterparts. This evolution in tractors is the direct result of continuing research advancements among its constituent disciplines. The ISO 11783 standard has and, continues to be, an active area of research within the agricultural engineering community. The standard of the task controller (TC), which is used for the operation parameters set up for tractor and implements, is described in part 10 of ISO 11783 (ISO11783-10:2015).
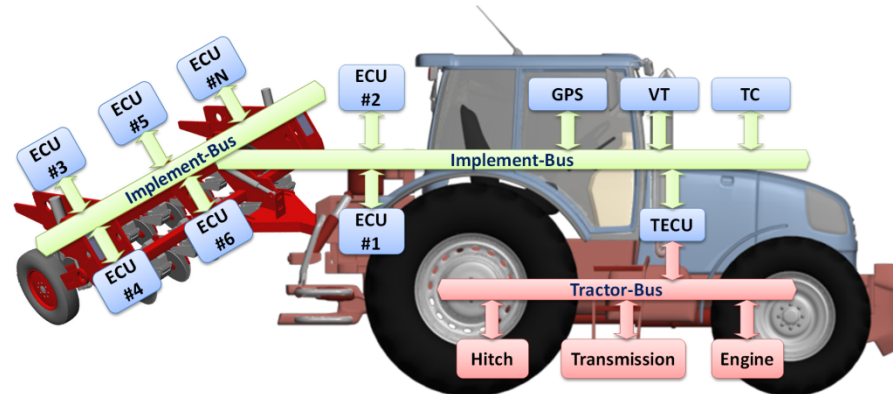

Fig .1 Agricultural tractor network structure based on ISO 11783 standard [10] [11].

The ISO 11783 standard establishes parameters for communication between ECUs in agricultural machinery and implements. This standard has fourteen parts, with eleven published by ISO, and started in 1991 by a committee of ISO from the union of two other standards, DIN 9684 Standards Association of German Deutsche Industrie Normen (DIN) and the SAE J1939 North American Society - society of automotive engineers (SAE) (ISO11783-3:2015). The standard DIN 9684 - Agricultural Tractors and Machinery, or standard LBS (Landwirtschaftliches Bus-System - Mobile Agricultural Bus) was developed in Germany by groups of companies and institutions associated with the DIN. The first version of the standard was completed in 1997, with five parties, two of which had great influence in the standard ISO 11783. The SAE J1939 (2007) - Recommended Practice for Truck and Bus Control and Communication Network - was developed by the committee SAE J1939 truck and bus control and communications subcommittee for applications in heavy vehicles such as buses, trucks and construction vehicles (Enkhbaatar, T., 2013). The working group (WG1) of ISO 11783 had the first discussions in February 1991, addressing the development of a standard connector and adopting the use of the latest standard CAN 2.0B. ISO 11783 can be simulated different software tools such as CANoe (VECTOR:2009). In this paper, the CANoe software tool is also used in order to clearly analyze TC and VT.

Task Controller

The data transfer is possible in two directions. The planned tasks are sent to the task controller (TC) on the mobile implement control system (MICS) and the results of the work are sent back to the farm management information system (FMIS) (ISO11783-10:2015). Tasks can be generated both on the FMIS and on the MICS. The architecture of TC core which has TC management, TC basic, TC-GEO and TC-SC /Section Control/ as shown in Fig-2(A). A task of TC-GEO and/or TC-SC should be running based on GPS position and some basic information of tractor which is transmitted via TECU (ISO 11783-7:2015) (ISO 11783-9:2012) is needed. The server-core-suite have application program interface for the task controller (TC), virtual terminal (VT), and file server (FS). Moreover, Fig-2(B) shows initialization procedure between TC and work machine ECU. Each ECU outputs the TC status message and the client task message at an interval of 2 seconds after an Address claim. Then, the worker ECU receives

various information from the ECU side and decides whether or not to upload the object pool. The object pool upload is done via the Transfer protocol (ISO11783-3:2014). Upload the object pool to the TC and activate the object pool, allowing the worker ECU to receive and process TC commands. Furthermore, TC can record the transmission message which is standardized in ISO 11783-10 and its data protocol is defined in online data base ISO 11783-11 (ISO 11783-11:2011). The online data base is critical to create a new task and analyze the process of this task such as recorded file.
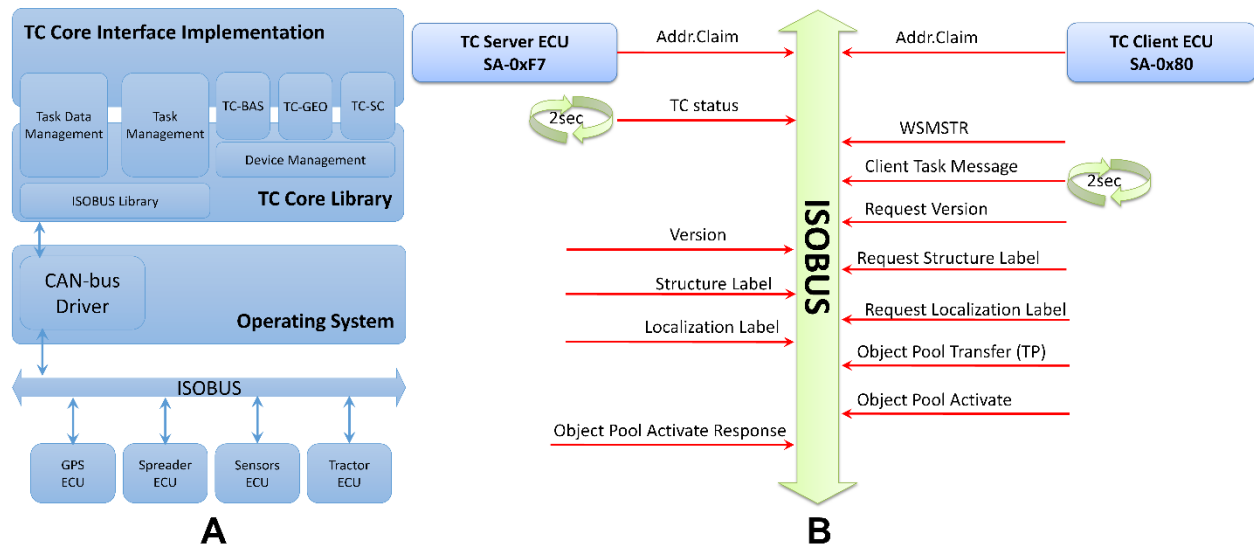

Fig. 2 (A) TC architecture and (B) Initialization procedure between a TC server and a TC client.

Analysis of ISOAgLibSE

The IsoAgLib was initially created by Achim Spangler as LBS-Lib within the subproject of IKB Duernast project as a doctoral student at Technical University Munich (TUM) – Crop production engineering –started in 1999 (Spangler et al., 2001). Now he is working for the company OSB AG and leads the evolution and upgrade of the IsoAgLib to the modifications of the ISO standards. The LBS-Lib is an open source way to stimulate use of open communication protocols in agriculture. Mentioning the static situation in LBS, a solution where every the implementation of the basic communication layer will stimulate the development of precision farming applications. With the progress in standardizing ISO 11783 has been "upgraded" to ISOBUS as IsoAgLib and now enables users to implement ISOBUS functionality. The documentation for news, changes, main features, structural overview of IsoAgLib, is presented on the http://ISOAgLib.org homepage (Spangler et al., 2010). Fig-3 shows connection between the user application layer and IsoAgLibSE interface which is used our developing clients.
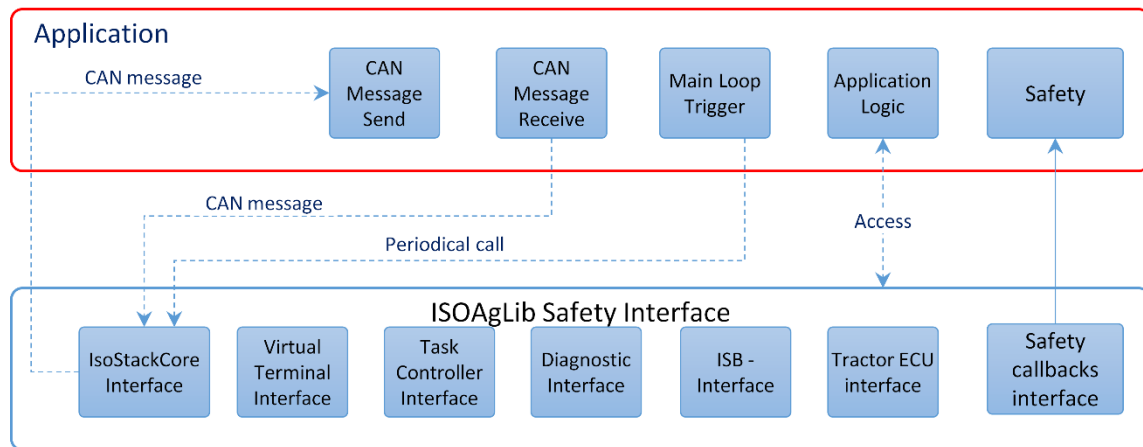

Fig. 3 Connection between the user application layer and IsoAgLib Safety Edition interface

VT and TC server applications are still developed by using server-core-suite library in our laboratory. Apart from this development, one of the ECUs is implemented and developed based on ISOBUS-stack as VT and TC clients. By using these development server and client applications, GPS, and TECU are simulated in this section. In order to test task controller with a simple task, the TC client has 3 section, 1 function, 1 device, and 1 connector elements. However VT and TC server application is working with different GUIs, these two application can be running simultaneously in this simulation environment. Also, VT and TC client function is combined in one console application. Fig-4 illustrates VT server application, which shows application rate of function element, TC task status, TC mode, and DL /Data Logger/ task status. Fig-5 illustrates TC GUI application in which TC client is already connected to TC server and upload object pools. This process described previous section. Moreover, this GUI application can be shown GPS position, active task, device elements, its objects and so forth. In this simulation, a task is created based on time log /TLG/ and includes device information on the MICS. The TimeLog element enables the collection of all DataLogValues in a binary-coded data log file. The created task and some recorded values are illustrated in Fig-8(A). There is also one of the xml file, TLG00000.xml, whose all attributes that refer to any values are considered to be fixed throughout all records of the binary file, "TLG00000.bin".
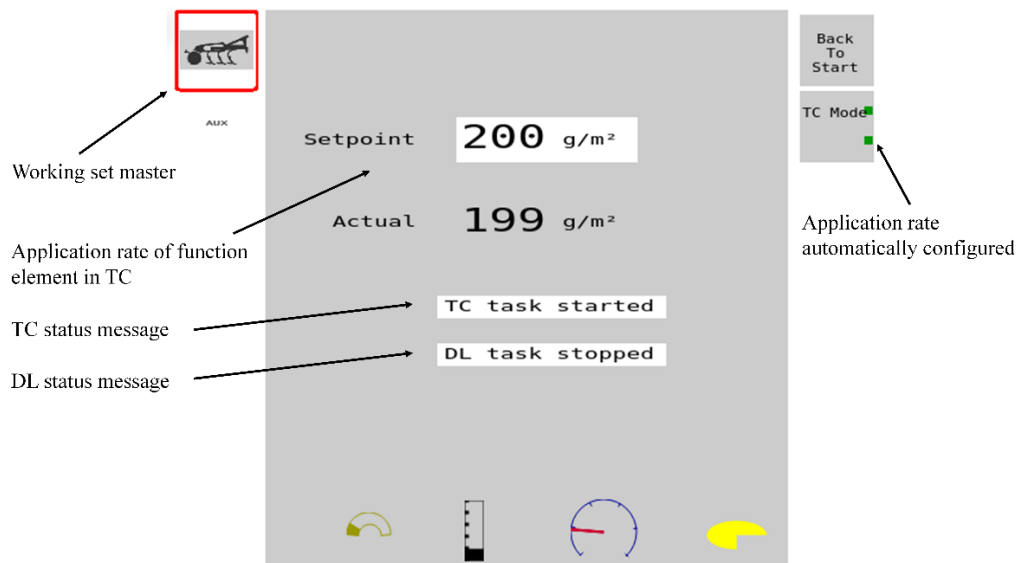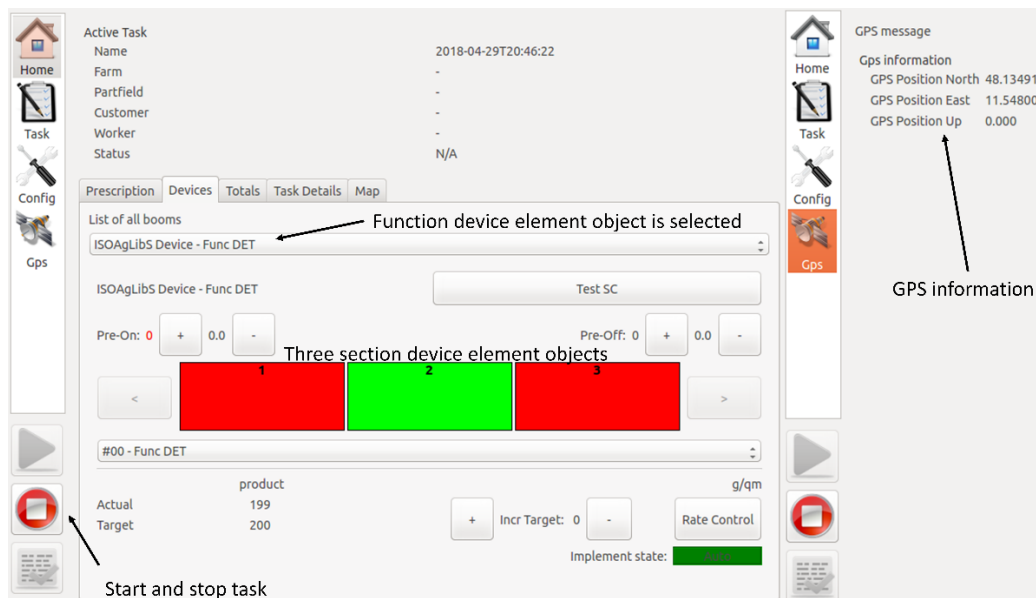

Fig 4. TC status on VT server application

Fig 5. Task controller server application with GPS server

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Analysis of CANoe with ISOBUS

Before implement an ECU, we simulated task controller with the vector sprayer ECU on the CANoe desktop application. The sprayer ECU has totally 9 device element objects in, which 5 sections, one function, one device, one bin, and one connector elements. In this example each section element has own application and flow rate, working width, reference points. Fig-6(A) shows TC diagram of sprayer ECU. Moreover, the simulation consists of GPS, TECU, Virtual Terminal, Interactive TC, Sprayer ECU, and ISO11783 network as shown in Fig-6(B). The simulation result as shown in Fig-7, one task which has one treatment zone whose application rate is 30 kg/ha. Based on GPS information which on GNNS monitor and volume and output tank of objects on VT, the task controller is working well and "taskdata.xml" which includes device, device objects, and task objects, is generated. The task has two treatment zone /TZN/ element, more and less treatment respectively. The TreatmentZone describes an area to be treated with the same process data DDIs and the same values as shown in Fig-8(C). Each treatment zone value is depending on GPS position and its simulation results can be show in J1939_Pos1 window of Fig-7.
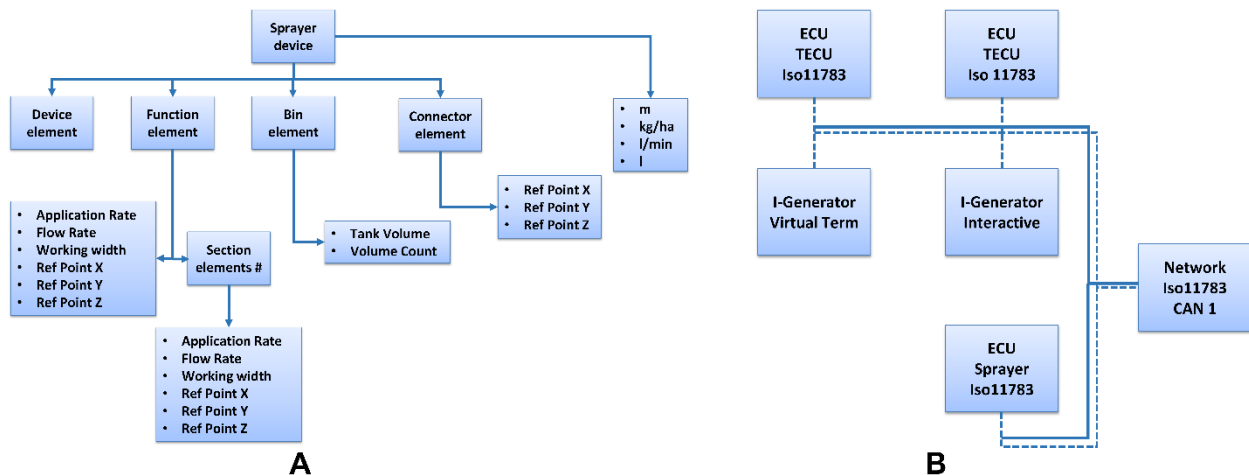

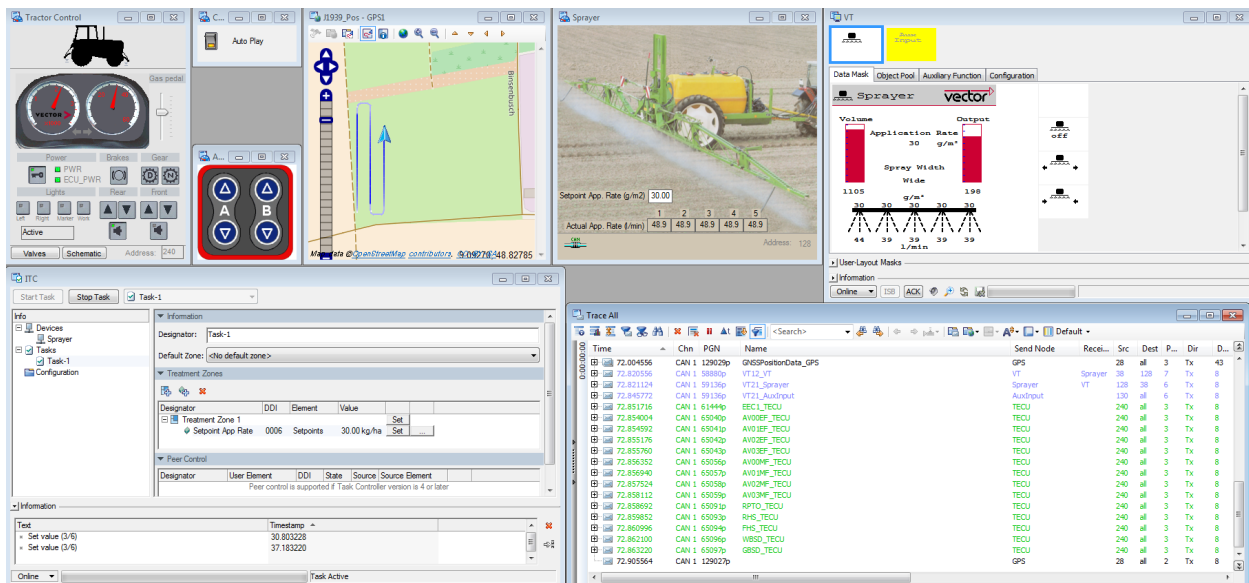**Fig-6 (A) Diagram of sprayer ECU and (B) ECUs on the implement bus**

Fig 7. CANoe simulation windows

Simulation results

We simulated two different task by using CANoe 9.0 desktop application and our developed Qt

application based on server-core-suite and ISO-stack libraries. CANoe desktop application can be controlled by any task which is created by user. However the task and connected ECUs information are written in "taskdata.xml", after finished this simulation a data logged file is not created. The simulation, which is based on server-core-suite and ISOBUS-stack, can be written process data messages as a binary file and each message corresponding data logging value. The data logging values are written in "TLG00000.xml" in this example. In other word, a FMIS can illustrate the task result to a farmer by using these binary and xml files.
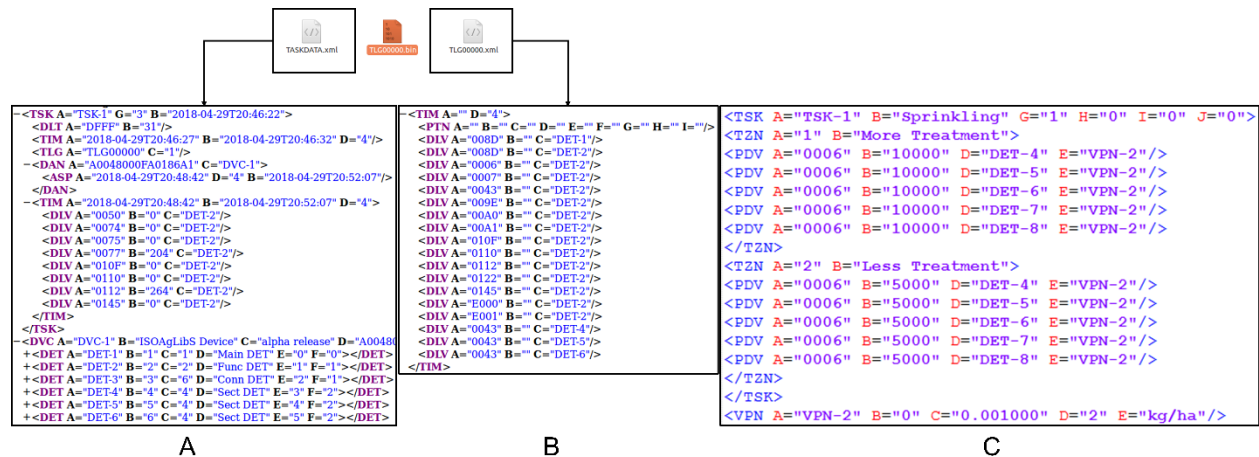

Fig 8. Generated task in (A), (B) TC application and (C) CANoe

Conclusion and future work

In this paper, VT and TC server which is based on server-core-suite library and Qt GUI are described. Also, all clients which is based on ISOBUS-stack and console application are explained. In addition, a planned task is created on MICS analyzed that how the task is running. We also simulated and analyzed TC and VT both server and client applications on CANoe by using ISO 11783 system test example. Nowadays, we have been working to integrate VT and TC server GUI application to one GUI application. Moreover, in order to create a task more precisely on FMIS and MICS, we analyze and implement TC element object such as treatment zone, time log and so forth by using the two libraries.

Acknowledgements

References

Enkhbaatar, T., Luubaatar, B., Hyeokjae, K., and Ham, W., "Design and Implementation of Virtual Terminal Based on ISO11783 Standard for Agricultural Tractors," presented at the 11th Int. Conf. Precision Agriculture, Indianapolis, Indiana, USA, Jul. 15-18, 2012.

Ham, W., Enkhbaatar, T., Luubaatar, B., Hyeokjae, K., "Implementation of ECU for Agricultural Machines Based on ISOAgLib Open Source", presented at the 11th Int. Conf. Precision Agriculture, Indianapolis, Indiana, USA, Jul. 15-18, 2012.

Hyeokjae, K., Enkhbaatar, T., and Woonchul, H., "Implementation of Virtual Terminal Based on CAN by Using WinCE Platform Builder 6.0," *Key Engineering Materials,* vol. 480, pp. 938-943, 2011.

ISO 11783-3, "Tractors and machinery for agriculture and forestry - Serial control and communications data network," Part 3: Data link layer, International Organization for Standardization, 2014.

ISO 11783-5, "Tractors and machinery for agriculture and forestry - Serial control and communications data network," Part 5: Network management, International Organization for Standardization, 2011.

ISO 11783-6, "Tractors and machinery for agriculture and forestry - Serial control and communications data network," Part 6: Virtual terminal, International Organization for Standardization, 2014.

ISO 11783-7, "Tractors and machinery for agriculture and forestry - Serial control and communications data network," Part 7: Implement message application layer, International Organization for Standardization, 2015.

ISO 11783-9, "Tractors and machinery for agriculture and forestry - Serial control and communications data network," Part 9: Tractor ECU, International Organization for Standardization, 2012.

ISO 11783-10, "Tractors and machinery for agriculture and forestry - Serial control and communications data network," Part 10: Task controller and management information system, International Organization for Standardization, 2015.

ISO 11783-11, "Tractors and machinery for agriculture and forestry - Serial control and communications data network," Part 11: Mobile data element dictionary, International Organization for Standardization, 2011. [Online]. Available: http://isobus.net/

ISO 11783-13, "Tractors and machinery for agriculture and forestry - Serial control and communications data network," Part 13: File server, International Organization for Standardization, 2011.

Pereira, R. R. D., Lopes, W. C., Sousa, R. V., Porto, A. J. V., and Inamasu, R. Y., "Object Oriented C++ Library IsoAgLib Study and Implementation from the Remote CAN-Based Distributed Control System", 9th IEEE International Conference on Control and Automation, December, 2011.

Stone, M. L., (1999). ISO 11783 an electronic communications protocol for agricultural equipment, for presentation at the Agricultural Equipment Technology Conference, Louisville, Kentucky, 7-10 February 1999.

Spangler, A., and Wodok, M.,"IsoAgLib–Development of ISO 11783 Applications in an Object Oriented way," ed, 2010.

Spangler, A., Auernhammer, H., and Demmel, M., "Stimulating Use Of Open Communication Standards In Agriculture (DIN9684 and IS011783) With Capable Open Source Program Library as Possible Reference Implementation," in Proceedings of the 3rd European Conference on Precision Agriculture, edited by S. Blackmore and G. Grenier, agro Montpellier, Montpellier, France, 2001, pp. 719-724.

Tumenjargal, E., Badarch, L., Kwon, H., and Ham, W., "Embedded software and hardware implementation system for a human machine interface based on ISOAgLib," *Journal of Zhejiang University-Science C-Computers & Electronics,* vol. 14, pp. 155-166, Mar 2013.

Tumenjargal, E., Badarch, L., Hyeokjae, K., and Ham, W., "Software Development Tool for Agricultural Machinery Based on IsoAgLib Open Source Library," presented at the 2012 ASABE Annual Meeting, Dallas, Texas, USA, Jul. 29 – August 1, 2012

VECTOR, (2009), "Automatic Interoperability Test for ISO 11783 Systems", Technical article, Vector Informatik GmbH, 2009. [Online]. Available: http://vector.com/portal/medien/cmc/press/PON/ISOBUS_ElektronikAutomotive_200910_PressArticle_EN.pdf