ISOBUS simulator for small and medium-scale manufacturers and farmers

Physics engine based HIL-ISOBUS-demonstrator

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Abstract: Among large-scale farmers and agricultural machinery manufacturers, ISOBUS is a universally accepted standard for controlling implements since it simplifies the implementation of precision farming on farms and agricultural machines. However, for small and medium-scale companies, being a farmer or an agricultural machinery manufacturer, the implementation of ISOBUS is often seen as a time-consuming and expensive challenge. For this reason, the authors built a modular simulation-based demonstrator to showcase such small and medium-scale companies the simplicity of integrating ISOBUS in farming systems and the efficiency of this technology to conduct smart farming. The present paper describes the mechanism by which the real ISOBUS terminal can control virtual agricultural machines modelized in a physics engine.

Keywords: ISOBUS, precision agriculture, simulation, physics engine

1 Introduction

Large-Scale agricultural machinery manufacturers and farmers are convinced about ISOBUS as a key technology to simplify the implement interface and to implement Precision Farming and smart farming technologies. However, the small and middle-scale companies' awareness about the importance of ISOBUS is still weak. In order to disseminate ISOBUS-technologies, a certain number of products have already been developed in the past. They can be used by sales departments on exhibitions [OE17], or at universities for teaching purposes [Bo10]. All existing solutions are hardware-only based. To realize a demonstrator which is easy to use, the authors chose to build a simulation-based demonstrator which mainly comprises a physics engine and a real ISOBUS terminal. Both are connected through Simulink and Canoe. The simulator includes the Universal Terminal and the TC-GEO ISOBUS functionalities.

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2 Materials and Methods

2.1 Field of application

A machine equipped with a front-loader and a manure spreader was chosen as main field of application. While the first one permits the user to test HMI-ISOBUS functionalities like UT and AUX-N [IS18], the second enables the test of precision farming ISOBUS functionalities such as the TC-BAS and the TC-GEO functionalities [IS15]. More precisely, UT makes the control of a fleet of machines with one single terminal possible and TC-BAS and TC-GEO enable variable rate application of crop protection products or fertilizers (Fig. 1).

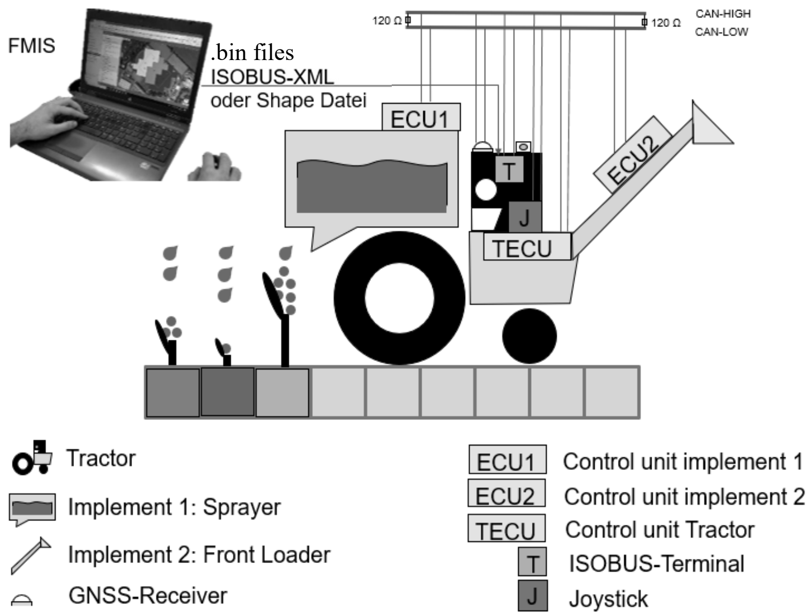

Fig. 1: ISOBUS system with spreader and front loader

2.2 Setup

The present demonstrator has two main parts: an actual ISOBUS terminal and a simulated ISOBUS-compliant machine – front loader (Fig. 2a) or sprayer (Fig. 2b). Real and virtual ISOBUS nodes are connected using a Vector CANCARDXLe PC-interface, the CANOE software (Vector Informatik GmbH) and Matlab/Simulink 18a. Thanks to a physics engine coupled to Simulink via UDP communication, it is possible to visualize the processed area like ground movements (Fig. 2a) or agrochemicals flow (Fig. 2b).

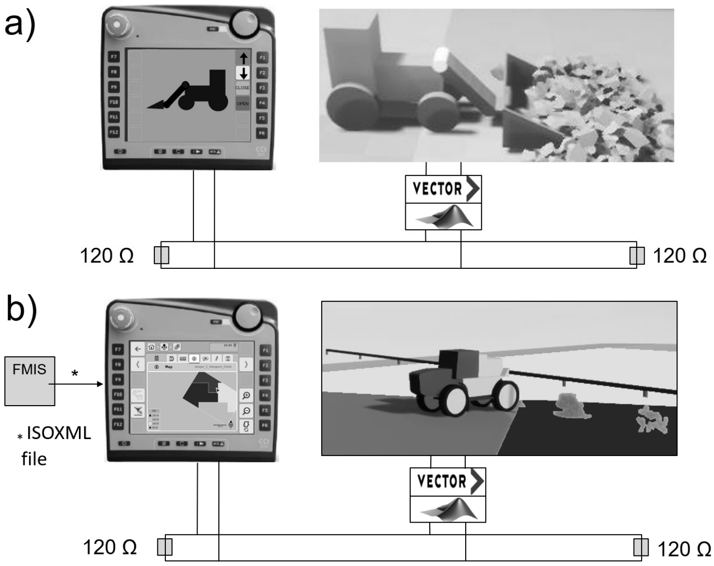

Fig. 2: Simulation-based demonstrator using the UT- (a) and the TC-GEO-Functionality (b)

As a transitional step before implementing ISOBUS on actual agricultural machines, a test box connected to the ISOBUS Terminal via ECU M10 can simulate the behaviour of a UT compatible implement. Additionally, to provide the test box with TC-GEO functionalities, a b-plus gateway must connect the ISOBUS Terminal and the ECU (Fig. 3b, Fig. 3c).

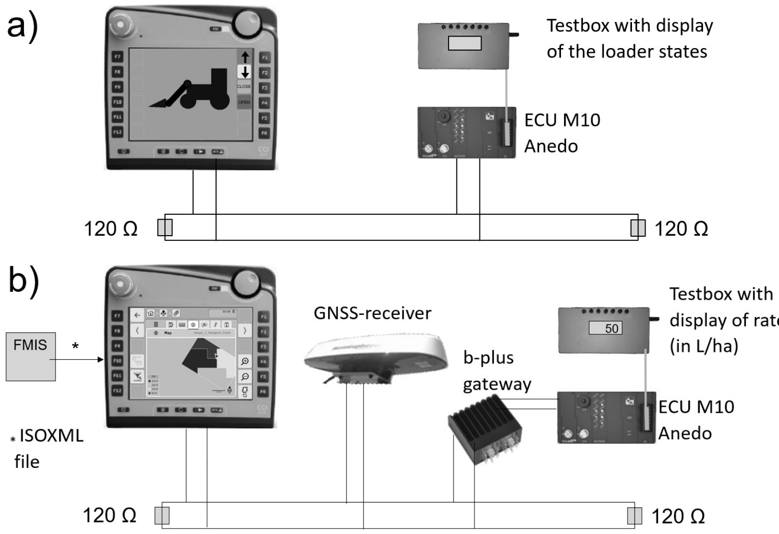

Fig. 3: Hardware-only based demonstrator: Test-Box

In addition to map-based Variable Rate Application (VRA) (Fig. 3a and Fig. 3b), it is also possible to perform sensor-based VRA (Fig. 3c). In this case, data from the N-Sensor is sent to the ISOBUS terminal via the protocol LH5000. The Connect App from CCI-ISOBUS transfers the data from the serial port RS232 to the Task Controller.

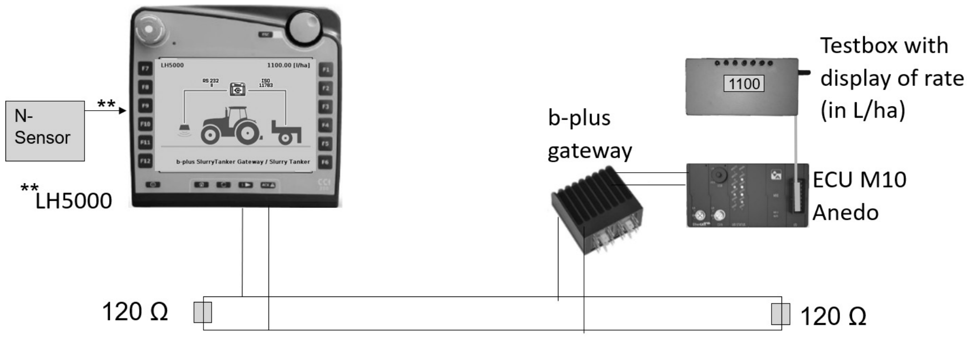

Fig. 4: sensor-based Variable Rate Application

2.3 Co-simulation between Real Terminal, Vector and a physics engine

The software CANOE (Vector Informatik GmbH) enables the communication between real ISOBUS nodes and virtual ones created in Matlab/Simulink (Fig. 5).
The farmers can directly see the spraying precision controlled through ISOBUS. Physics-engine-based simulations allow for getting plausible and rendered results of ISOBUS deployment scenarios. Thanks to the physics engine and the particles technology, it is possible to visualize the processed area and the flow of fertilizers or pesticides. The number and size of particles will depend on the flow of pesticides.

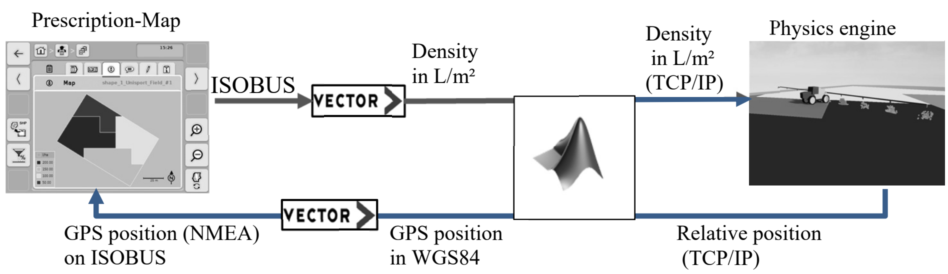

Fig. 5: co-simulation between the real ISOBUS-terminal,
Vector, Matlab/Simulink and the physics engine

2.4 Simulink- and physics engine models

The physics engine model consists mainly of a 3D-multibody-mechanical-model of an agricultural machine and a terrain model. In order to provide Simulink Control-Loops with actual positions of the Tractor-Implement-System, some sensors are implemented in the physics engine as well. It is possible to adjust the level of determinism and to consider or not 3D-Bodies as cinematics or dynamics body, depending on the user-cases.

The Simulink models have two main functions. The first one is to convert the ISOBUS signals coming from the ISOBUS terminal via the software Canoe into physical values, which can be interpreted by physics engines, such as the position of mechanical parts or the quantity of liquids to be sprayed. Its second function is to set the speed and steering of the tractor to be transmitted to the physics engine. The tractor can be controlled automatically using a state machine or manually using a keyboard or a joystick.

Finally, the Matlab-Simulink model can be improved by the implementation of additional control loops for electrical and hydraulics actuators.

2.5 Development of the demonstrator

The development of the demonstrator can be summarized in 5 steps:

- Development of ISOBUS Object Pools with Jetter's ISO-DESIGNER
- Configuration of the virtual ISOBUS-network with Vector's CANOE
- Matlab/Simulink modelling of the agricultural machine, using Simmechanics, the Vector-Simulink-Toolbox and UDP-communication blocs
- Physics engine modelling of the agricultural machine
- ECU-programming with Codesys (in case of using the test box)

3 Results

The first VT- and TC-GEO simulations agree well with our expectations. Namely, operating a virtual UT- and TC-GEO compliant ISOBUS agricultural machine requires the same procedures as for a real machine. Using the demonstrators' actual ISOBUS terminal, the user can fill the bucket of the virtual loader and can spray on the virtual field at a variable rate controlled by the prescription map imported previously. (taskdata.xml imported from the Farm Management Information System into the terminal). In terms of Human Machine Interface, the virtual environment is quite responsive to the user inputs. The same user can clearly identify the processed area and the process variations – flow of agrochemicals or of loaded material – which both depend on the machine parameters.

This paper filled some lack of knowledge in terms of ISOBUS training systems. It introduced a simulator for different ISOBUS-based agricultural practices which is configurable depending on the users, being a farmer or a research and development engineer.

The simulator enables the farmers to appreciate and engage the different ISOBUS functionalities in a safe-environment. It allows developers of ISOBUS applications to create and test their solutions and consequently to reduce the number of cost-consuming tests with real machines.

4 Conclusions

The use of a modular and easy to use simulation-based demonstrator is a promising approach to demonstrate to small- and medium-scale companies, being a farmer or an agriculture machinery manufacturer, how ISOBUS could be applied to their farms or their products respectively. While Hardware in the Loop (HiL) permits to create user-scenarios close to their real-life counterparts, the use of physics engines enables a realistic and precise simulation of the agricultural machine. In the future, new features will be implemented in order to cover a wider range of scenarios. In the coming weeks, the demonstrator will be updated to enable section-control applications.

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References

[Bo10] Bosse, D.; Kinder, T.; Dzinaj, T.; Klose R.; Ruckelshausen, A.: ISOBUS-demonstrator for research and education in Landtechnik, S. 261-263, 2010.

[IS18] ISO: Virtual terminal. ISO 11783-6, Geneva, 2018.

[IS15] ISO: Task controller and management information system data interchange. ISO 11783-10, Geneva, 2015.

[OE17] OEM Off-Highway: Anedo Debuts open:system Control Concept for Machine Automation at bauma, 2017. https://www.oemoffhighway.com/electronics/press-release/12208727/anedo-debuts-opensystem-control-concept-for-machine-automation-at-bauma, Stand: 10.12.2019.