ROBS4CROPS

D2.5 Report on TIM implementation (1)

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101016807

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Work Package	WP2
Delivery Date (DoA)	31 Dec 2022
Actual Delivery Date	23 Dec 2022
Abstract:	The script will represent the progress of the work regarding the implementation of ISOBUS TIM functionality. The preliminary results of the TIM functionality, in terms of proprietary message-based communication for the TIM, that has defined for the emergency stop will be explained.

Document Revision History			
Date	**Version**	**Author/Contributor/ Reviewer**	**Summary of main changes**
23 December 2022	1	G. Sharipov & D.S Paraforos (UHOH)	Initial version

Dissemination Level		
PU	Public	**Yes**
PP	Restricted to other programme participants (including the EC Services)	No
RE	Restricted to a group specified by the consortium (including the EC Services)	No
CO	Confidential, only for members of the consortium (including the EC)	No

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Funding Scheme: Innovation Action (IA) • Topic: H2020-ICT-46-2020

Start date of project: 01 January, 2021 • Duration: 48 months

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List of Abbreviations and Acronyms	
FC	Farming Controller
VT	Virtual Terminal
ECU	Electronics Control Unit
IBBC	ISOBUS breakaway connector
CAN	Controlled Area Network
WUI	Web User Interface
GUI	Graphical User Interface
PTO	Power Take-Off
PWM	Pulse Width Modulation
TIM	Tractor Implement Management
AEF	Automotive Engineering Foundation
TECU	Tractor ECU

1 Intro: Tractor Implement Management (TIM)

TIM is a very recent functionality of the ISOBUS from AEF that optimizes the quality and efficiency of the communication between the ISOBUS-compliant tractor and the implement. The main concept of the TIM is to bring intelligence to the entire communication between the agricultural implement and the tractor. This is supposed to be done by the implement since the operated field applications and sequences followed, in terms of the process data such as as-applied information, are known to the implement due to the ISOBUS-compliant ECU of the implement that communicates with the external sensors. At the same time, the ECU communicates with the TECU. Therefore, the ECU can take control on some occasions when there is a need to change the ground speed/ stop the tractor/ change the PTO speed and command the TECU of the tractor.

In the Robs4Crops project, the pilot sprayer and weeder cases are equipped with sensors and software to transform the implements into smart implements.

For the case with the sprayer, the parameters that TIM functionality of the ISOBUS should take control of are:

- Emergency STOP
- PTO speed (ON/OFF - not finalized)

For the case with the weeder, the parameters that TIM functionality of the ISOBUS should take control of are:

- Emergency STOP
- Hitch position

2 TIM implementation based on a proprietary message-based communication in Weeding

The emergency STOP of a vehicle is one of the functionalities of TIM. This functionality has been implemented for the combination of the CEOL robot and the mechanical weeder. The implementation is based on the proprietary message of ISOBUS since the mechanical weeder is not designed with a real ISOBUS-compliant ECU. Besides that, the simulated ECU of the weeder can't run the AEF certificate for the TIM functionality of the ISOBUS. Therefore, all the parameters of ISOBUS TIM that have/are/will be implemented stay at a proprietary message level. Figure 1 shows the flow of the implemented proprietary message for the emergency STOP in the weeding case with the CEOL robot.

The Analytics software is responsible to make the decision of "Emergency STOP" based on information from the external sensors that indicates that the weeder is blocked (with crop residue and/or other material) and the weeding quality. The decision of the Analytics is transferred to the middleware through the "Virtual Channel" which is designed as one of three bridges of the middleware. The bridge puts the signal of emergency stop into the ISO11783 network of the middleware. The middleware software (CANoe) contains a dedicated node (highlighted with a red box in Figure 1) on the ISO11783 network that carries out the conversion of the emergency stop signal to the ISOBUS-compliant signal. The converted ISOBUS signal of Emergency STOP instantly pops up on the VT for operator acknowledgment since the VT is directly connected to the ISO11783 network of the middleware using one of the two channels of the VN1610 CAN Interface. Concurrently, the converted signal, which is placed on a proprietary message of ISO11783 protocol, is sent to the AGC-Box of the CEOL robot using the second bridge of the middleware. The second bridge is designed to contain the J1939 protocol to communicate with the vehicle side of the configuration.

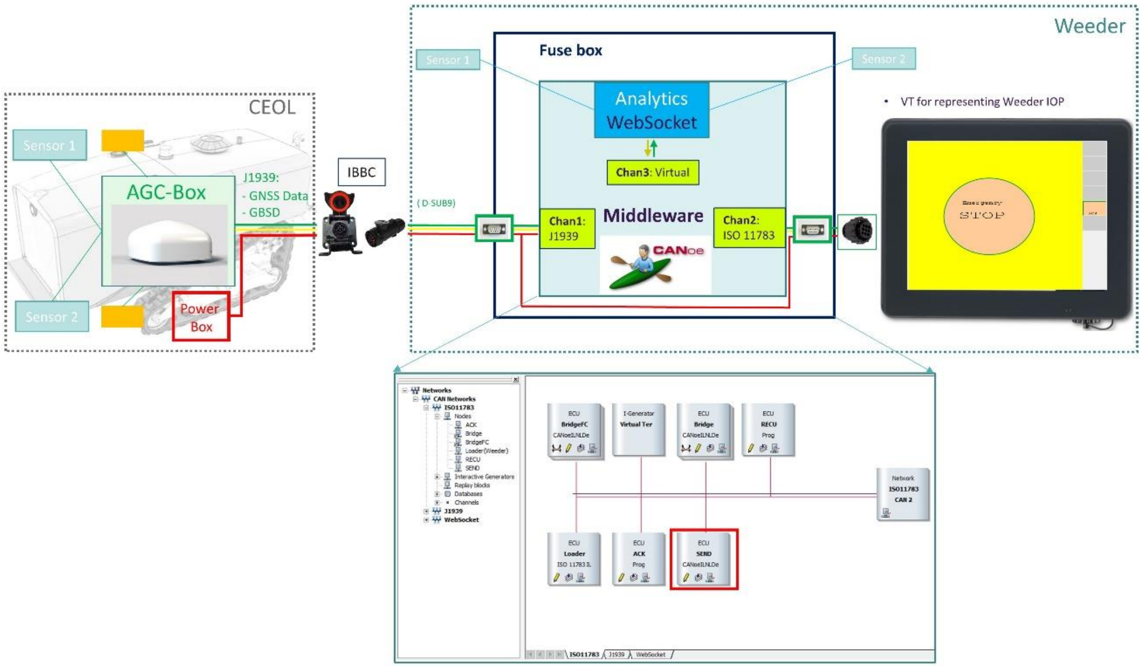

***Figure 1**. Emergency STOP using the proprietary message of TIM. The message is generated by the Analytics software when sensors indicate that the weeder is blocked (with crop residue and/or other material) or when the weeding quality falls below a threshold.*

Table 1 below describes the parameter that is controlled by the TIM functionality of the ISOBUS. Besides that, it includes information about the task that needs to be done for implementing the ISOBUS TIM. The current status of the implementation, in terms of what is achieved and what further needs to be done, is described.

***Table 1**. Parameters of TIM functionality for the weeder case*

Partner	Description of Task	Current status of the task	Parameter to implement
UHOH	A proper signal from ISO11783 protocol for the TIM functionality needs to be implemented for the communication between the implement and the robots. The middleware needs to be designed with a dedicated node of the	The signal from the ISO 11783 database has been defined to characterize and send the emergency stop signal of the ISOBUS TIM. The dedicated node in the middleware will be	Emergency STOP ON/OFF state for the hitch

	ISO11783 network that plays the role of the certificate for the TIM functionality of ISOBUS	designed to play the role of ISOBUS TIM. The dedicated node will be responsible to transfer the proprietary messages of the TIM to the robots.	
WR	An algorithm that considers the sensor data to determine the weeding quality/blockage needs to be developed. The Analytics decides about the emergency stop or shifting the implement (OFF state) and sends the decision to the middleware.	The algorithm has been developed for evaluating the weeding quality/blockage. The emergency STOP signal is implemented. The algorithm for shifting/putting down the implement (ON/OFF state) from/to the ground should be developed and a proper signal should be implemented to send the decision to the middleware	Emergency STOP ON/OFF state for the hitch
AGC	The CEOL robot should be able to receive the ISOBUS-compliant signals of the TIM, in terms of emergency STOP and ON/OFF work state for the hitch.	The CEOL robot is already able to receive the signal for the emergency STOP through the AGC-Box. It has been implemented and tested. The same algorithm should be implemented for receiving the ON/OFF state signal from the middleware.	Emergency STOP ON/OFF state for the hitch
AGI	The Robotti should be able to receive the ISOBUS-compliant signals of the TIM, in terms of emergency STOP and ON/OFF work-state for the hitch, through the CANBUS of the robot.	The current status is that the Robotti is not able to receive any signal through its integrated CANBUS system.	Emergency STOP ON/OFF state for the hitch

In the combination of the weeder with the Robotti, the above-described workflow/developed algorithms/configurations will be identically implemented for the

Middleware and the Analytics software as soon as the CANBUS system of the Robotti is modified to receive the signals of the ISOBUS TIM.

3 Testing protocols for the TIM in a simulated environment in the middleware

To be able to implement the part of the ISO 11783 protocol for the TIM functionality of ISOBUS in the developed configuration of the Middleware, the dedicated node for the TIM has been developed under the simulated environment of the Middleware software and is under investigation. The simulated nodes of ISOBUS TIM and the configurations for the simulated environment are presented in Figure 2.

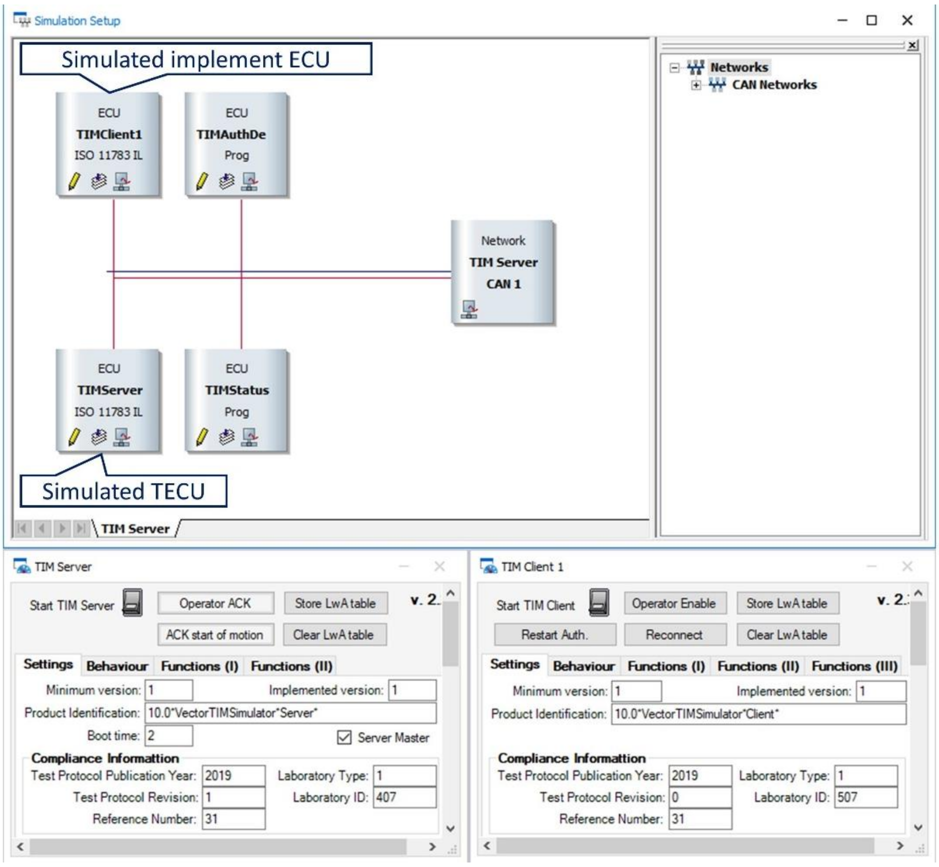

Figure 2. *The simulated configuration of CANoe for the implement and vehicle communication.*

In this configuration, the TIM server is the vehicle ECU and the TIM client is the implement ECU. The configuration contains one TIM Server and three TIM Clients. After confirming "automation" in the control panel, each function of the TIM Server via the corresponding TIM Client can be controlled. Our main aim in simulating the TIM functionality is to prepare the proprietary message containing our target signals from the ISO11783 base for the implementation of ISOBUS TIM into the configuration that is described above in Figure 1. Besides that, the CAPL functions for the dedicated node are/will be developed in the simulation setup at first. The address-claiming procedure between the implement ECU and the TIM node also should be considered.

4 Discussion of current status and future implementations

As preliminary details are described in Table 1, the current status of implementing the ISOBUS TIM functionality has only been carried out in the combination of the weeder with the CEOL robot. For this combination, the parameter of the ISOBUS TIM is the emergency stop of the Robot which is the decision made by the Analytics software. The signal from the ISO 11783 database has been defined to make the emergency stop signal compliant with the ISO11783 network. Subsequently, the ISOBUS network of the middleware transfers it to the robot through CANBUS. The further steps of this combination should be upgraded by including the hitch work state of the CEOL robot. For that, a proper signal/message from the ISO11783 base shall be defined and the same methodology as the implementation of the emergency stop will be applied.

In the combination of the weeder with the Robotti, the same signals/messages from the middleware (ISO 11783 base) and the same algorithm are supposed to be applied. However, the ECU of the Robotti will be modified for receiving the ISOBUS TIM messages that are described above. Due to the incapacity of the Robotti for receiving ISOBUS messages through its CANBUS, the current status of this combination does not involve any implementation of ISOBUS TIM functionality, in terms of the proprietary messages defined for the ISOBUS TIM.

The TIM functionality of the ISOBUS for the sprayer with the Tractor is not yet initiated. Since the sprayer is designed with a real ISOBUS-compliant ECU, the process of implementing the ISOBUS TIM functionality is supposed to include the followings:

- The ECU of the Sprayer needs to include ISO11783 library for the parameter of the TIM functionality based on process data (as-applied information)
- The ISOBUS TIM functionality (AEF certified) should be activated on the VTs
- The middleware still needs to be responsible to communicate (transferring the ISOBUS messages to) with the Tractor/CEOL since they both is not integrated with the ISOBUS-compatible TECU functionality

On the other hand, the current status of the sprayer ECU and the selected VT are able to operate with the variable rate application (VRA) of spraying. Therefore, the work state of ON/OFF for the sprayer is already integrated with the ECU of the sprayer.