Deliverable Report

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EIT Food – Making Food Innovation Happen

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EIT Food is Europe's leading agri-food innovation initiative, with the aim to create a sustainable and future-proof food sector. The initiative is made up of a consortium of key industry players, start-ups, research centres and universities from across Europe. EIT Food aims to collaborate closely with consumers to develop new knowledge and technology-based products and services that will ultimately deliver a healthier and more sustainable lifestyle for all European citizens.

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1. Executive Summary

The main expected outcome and impact of this activity is to reduce the herbicide input, herbicide residues in the food chain and costs of weed control. Currently all new tractors have ISOBUS, and ISOBUS control integrated into them. Therefore, variable rate application for herbicide applications in a grosser or finer scale can be achieved. The targets of the current project were to proceed forward in the creation of an online herbicide spraying tool only for weed infested areas. Until now there aren't any market solutions for weed identification that can use the ISOBUS. By creating an ISOBUS enabled platform the weed identification and the treatment decision is separated from the actual actuation. Images were acquired, and Neural networks (VGG16, ResNet50, Xception) were trained for weed recognition in this project, the DSS support system decided where to spray or not, on 25 by 25 cm grids and coordinated the application with the ISOBUS enabled sprayer. The final milestone and deliverable of this project was the lab demonstration / simulation of a prototype sprayer. Due to COVID-19, the demonstration could not be performed at JD labs but a simulation of the system (combining all the pieces from the 3 different partners of two different countries) was created at the end of the year on each partner independently and compiled as a demonstration video. The video is available at :

https://projects.phytomed.uni-hohenheim.de/nextcloud/s/wD688QjciMYxfcy

In the below text we will explain some of the ideas, technical problems, and solutions presented in this video, along with further information / prerequisites for the system to work, and for the work that was done into creating a similar setup for mechanical hoeing.

2. Delivery of work

The current setup is using RGB images acquired from a high resolution camera. Each image is separated into 25 by 25 cm grids, with the field of view of each grid representing the application area from each respective nozzle. For each grid a preprocessing was performed, to acquire the important regions of interest (ROI). This preprocessing was similar to the preprocessing done for the acquisition of the label – images (ROI) used for the training of the Neural Networks (NN). Each new label – image was fed to the NN to get the appropriate classification. ResNet50 was used as the classification network showing the best trade-off between classification time per label – image and classification accuracy. Furthermore, to reduce the load of the classification procedure of the network, statistical information of the expected crop density, parallel identification of label - images from different grids, and information on the Decision Support System (DSS) thresholds were taken into account into the load priority of the different label – images. When the weed density of a specific grid overpassed the desired threshold from the DSS, then that grid was flagged as a sprayed grid, and further label – images were ignored. Figures 1 and 2 are showing snapshots of the described video where the first layer is the original image separated into 25 by 25 cm grids. The second layer represents the identification result from the NN, the third layer is the overall spray /not spray result of the DSS and finally, in the last layer, the actuation (spraying) was performed.

An ISOBUS Task Controler (TC) gathered the data of one or more grids and based on their geometry compacted all these data together and through the appropriate TC Server it can communicate with any standard ISOBUS enabled section controlled sprayer that exists on the market. Yet, since sensor controlled variable rate applications are not fully standardized on the ISOBUS protocol we had to modify the Section Control part of Task Controller Server in a way that the Section Control Work State merged information of both, the TC client of our Sensor system and the TC client of any ISOBUS Sprayer enabling them to flow into the same coverage map (Figures 3 and 4). When the sensor recognized a grid as a “weed - free” grid, that would overlay this area on the map as “covered” already, therefore the sprayer would not spray it. Using the TC coverage map for merging of information has one very big advantage: The number of sections you define for the sensor is completely independent of the available number of sections of the sprayer and will work with any ISOBUS sprayer on the market that works with a coverage map (typical ISOBUS sprayers). The TC Server would not specifically command the sprayer where to spray or not, it just flags the “weed-free” regions as sprayed already.

To execute the site-specific information of the developed communication protocol in the field for both chemical and mechanical weed control a prototype carrier was developed that is able to manage weeds targeted mechanically and/or chemically. Row widths differ both between crops and regions. To make the results of the project available to a wide range of customers a row width of 25cm was selected. This allows the usage of the prototype in wide row cereals as well as in traditional row crops planted in 50 or 75cm row widths such as corn or sugar beets. JD developed an existing 3m cultivator as carrier vehicle. For mechanical weeding in 25cm crops, 2 to 3 rows were combined to one control unit (parallelogram). A detailed overview of the cultivator setup is shown in Figure 5 below. The outermost rows on the left and right side of the toolbar can be folded to meet road regulations. For the execution of site-specific weed control hydraulic cylinders were added to each parallelogram to actuate those based on the sensor signal.

Concerning the spraying platform, it was decided to use an existing front mounted spraying tank and add an aftermarket solution to the cultivator units in order to have maximal flexibility within the setup. Hereby two targeted spraying approaches could be realized. Band spraying between and within the rows (blue circle in the schematic) and targeted under-leaf spraying (orange triangles in the schematic). For the actuation of the nozzles, a Teejet system was used with electric nozzles drivers which allow pulsing of the signal. Terminal visualization is shown in Figure 6, while the final prototype is shown in Figure 7.

2. Conclusions - Outlook

With the current setup, it was feasible to demonstrate the capabilities and the concept of the current realization. Hardware and software limitations (eg processing power, ISOBUS standard) have enforced us to select the most feasible and prominent trade-offs, while the DSS algorithms were modified to facilitate as much as possible a timely outcome for online – application purposes. Even if peer to peer communication in ISOBUS exists, ISOBUS sensors for online applications are limited. The current project provided us an insight on the problems existing on that front and a discussion about coverage merging has started in the TC standardization group. Yet, even with the current setup by the appropriate modification of the tractor TC Server the system can use any ISOBUS sprayer.

3. Annexes

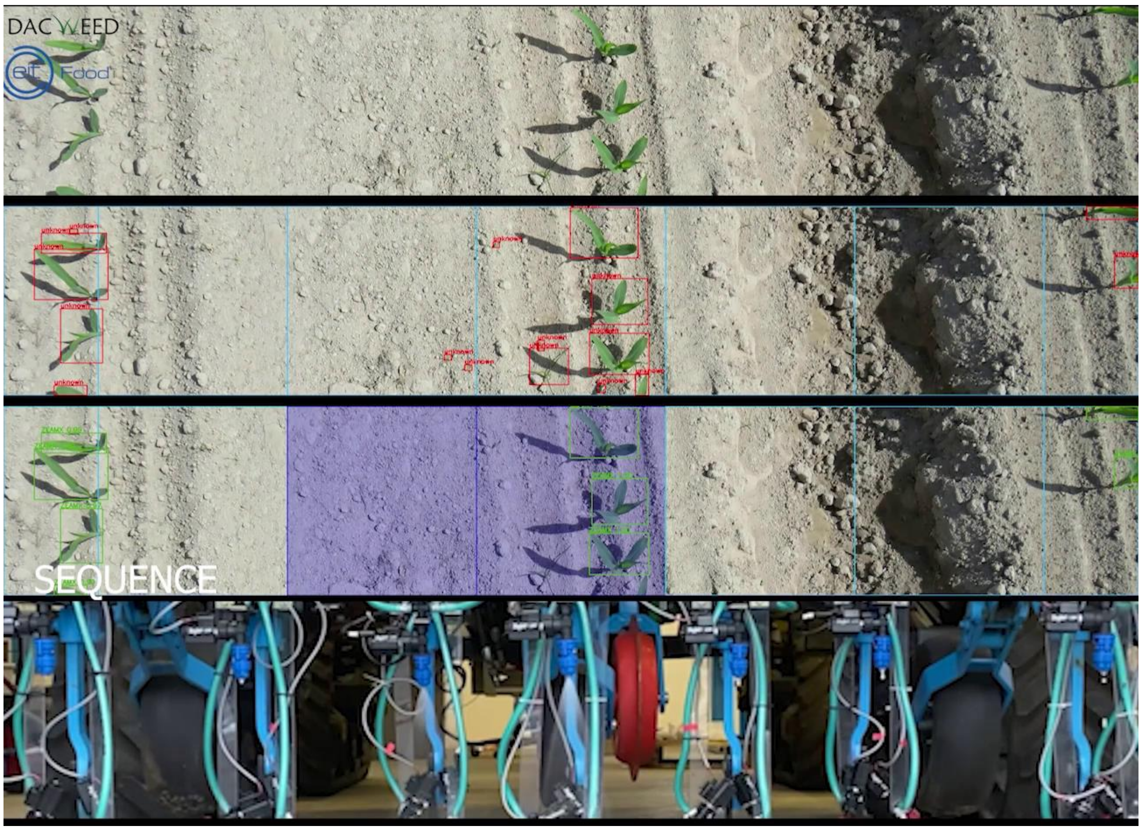

Figure 1: Snapshot of the demonstration video. The first layer is the original image separated into 25 by 25 cm grids. The second layer represents the identification result from the NN, the third layer is the overall spray /not spray result of the DSS and finally, in the last layer the actuation (spraying) was performed

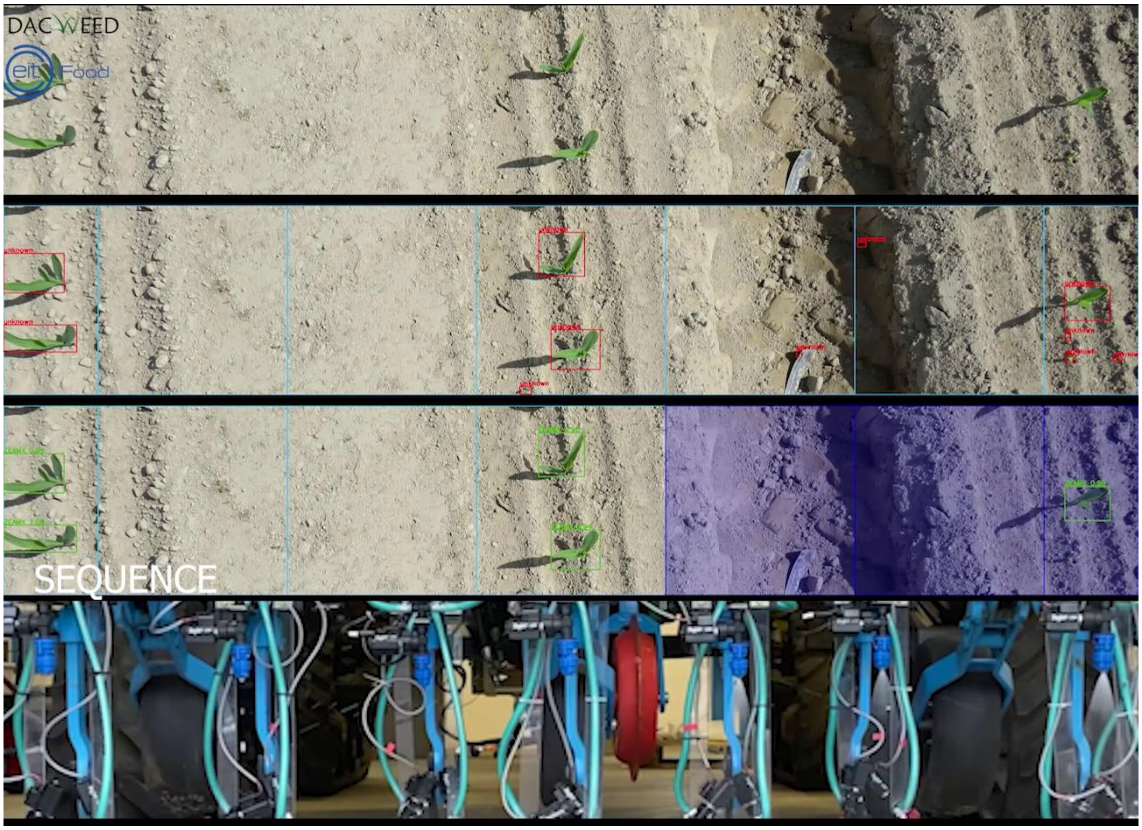

Figure 2: Snapshot of the demonstration video.

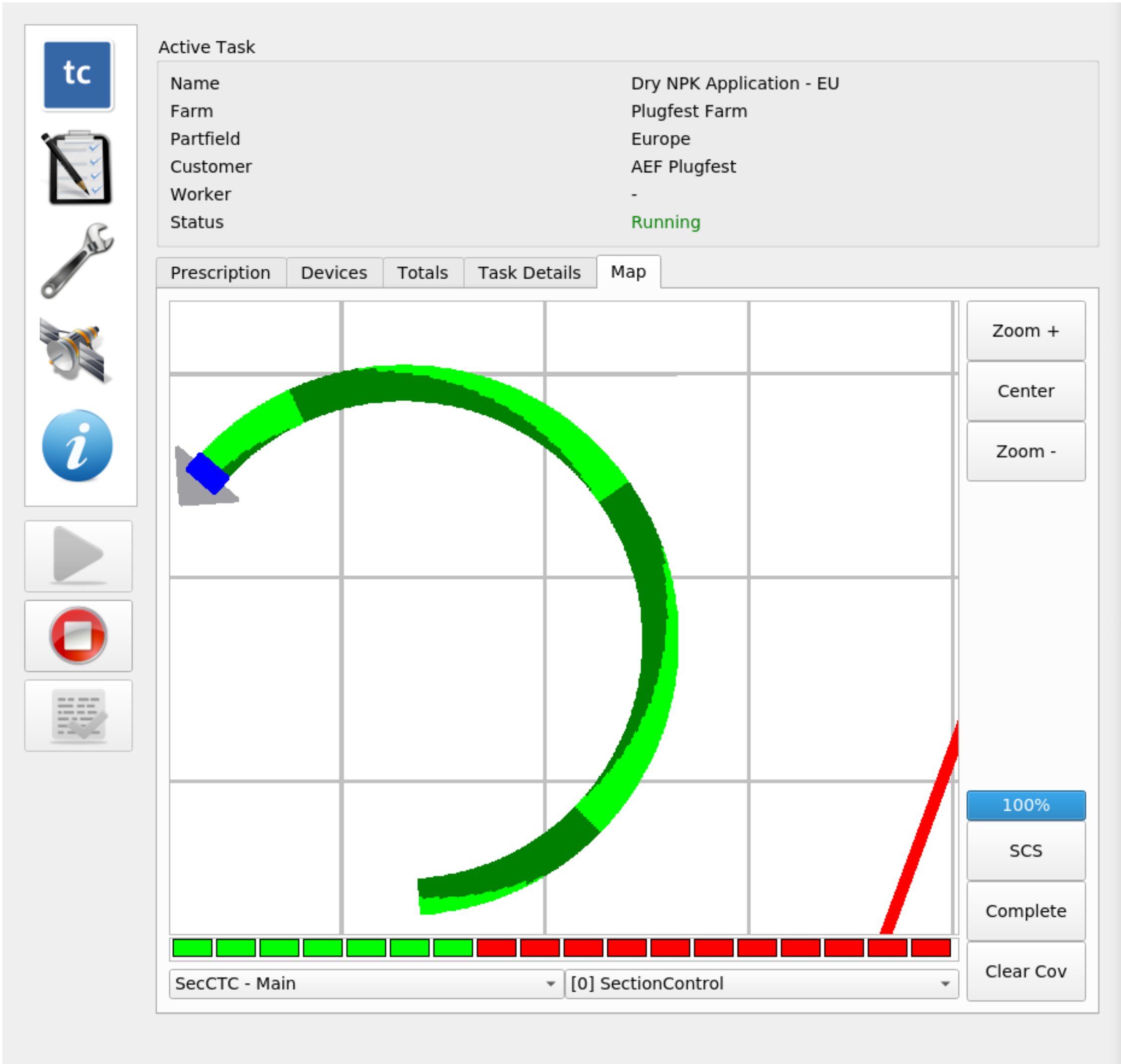

Figure 3: The coverage map of the sensor. The tractor is moving in a circle. Dark green are “weed – free” regions while light green are the regions that need to be sprayed.

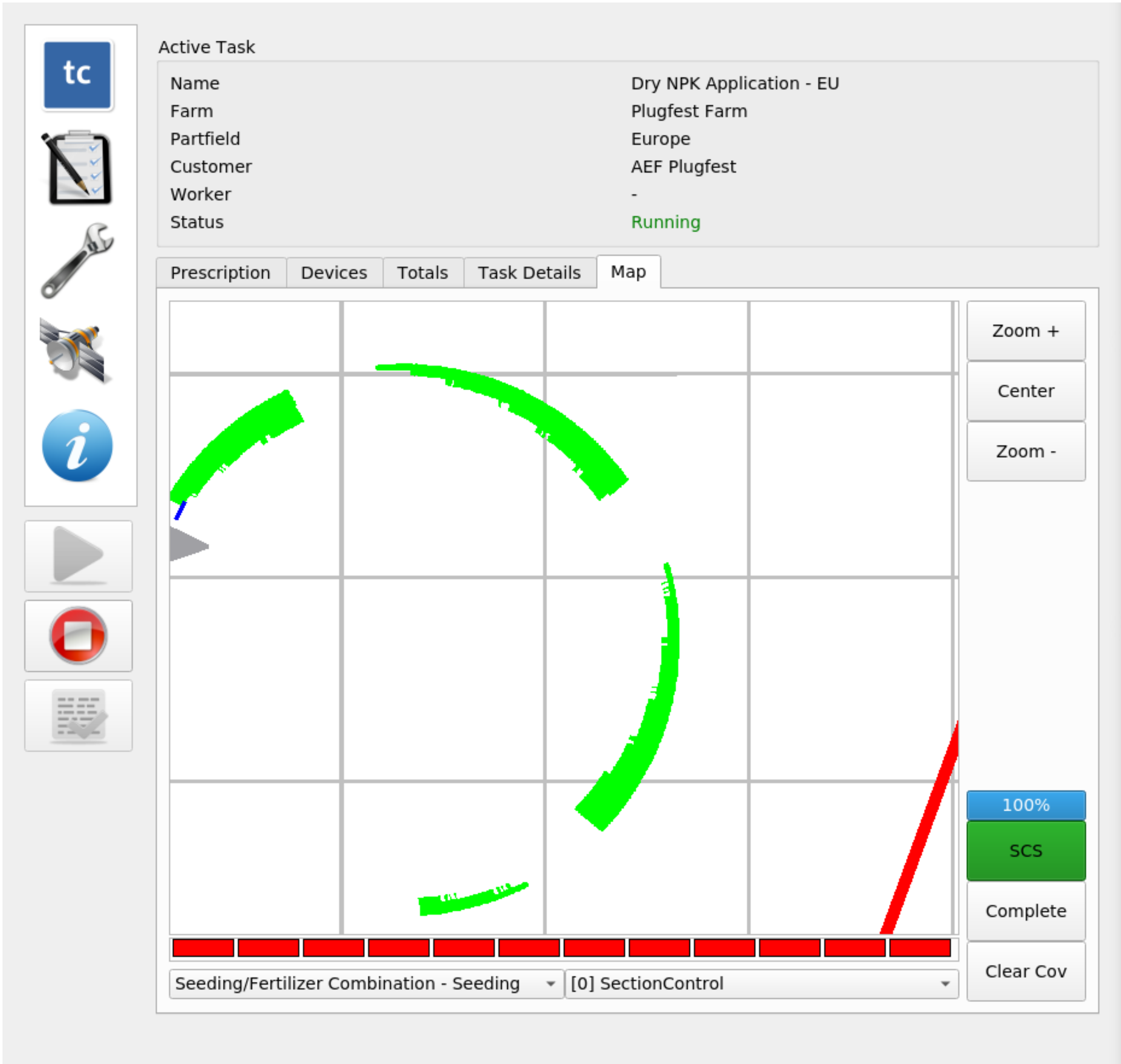

Figure 4: The coverage map of the sprayer. The tractor is moving in a circle. Light green are the regions that were sprayed.

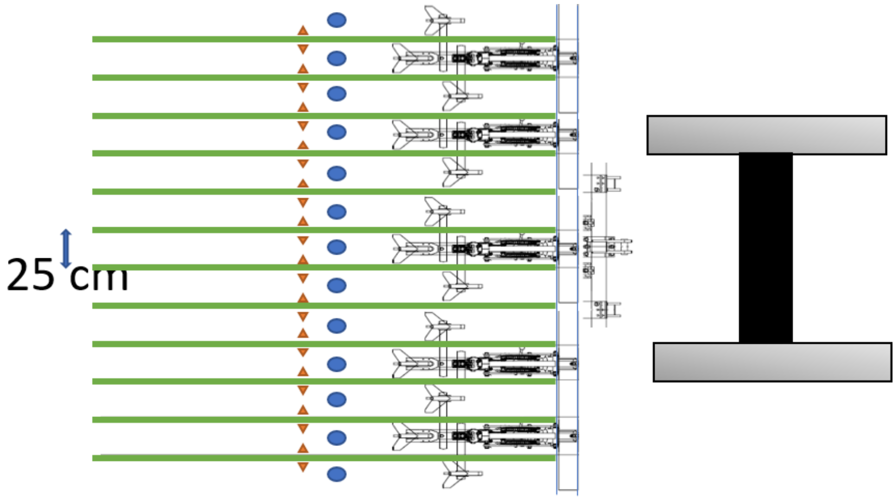

Figure 5: Schematic Overview on the arrangement of the cultivator tines as well as the spraying nozzles

Figure 6: Terminal Integration

Figure 7: Final Prototype