D1.1: Robotics-related Technologies Mapping for application in the Agri-Food sector

Resubmission – Answers to review comments

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Recap

The data collection for our first report (D1.1, May 2020) was based on a survey in PDF format because it could be nicely formatted and kept to two pages. Keywords were selected to be relevant and comprehensive. The survey was supplied in English only and emailed to the 143 people on the Basecamp communication portal used by agROBOfood. In addition, some partners forwarded the survey to external contacts. The survey was sent out in February 2020 with reminders sent in March and April 2020.

Disappointingly, only 16 replies were received, nine of which came via the five RTOs responsible for the deliverable. 12 tech developer companies were represented and 10 of these were not directly connected to agROBOfood. Of the 12, six were large enterprises (AEF, CLAAS, Continental, Fendt, BA systems, and Veris), two were SMEs, three were start-ups and one was unknown.

Descriptions of the 16 technologies showed that 6 were for arable (field) technologies, two were livestock, one was for food preparation (low-TRL), four were fairly generic ideas suggesting technology side-stepping from the industrial domain, two were about data security and certification, and the last one recommended ROS for prototyping.

Received feedback based on review of D1.1

The D1.1 was not accepted due to the comment as follows:

Expert opinion on deliverables

Deliverable number	Deliverable name	Status	Comments
D1.1	Robotics-related Technologies Mapping for application in Agri-Food sector	Request for revision	This deliverable does not provide the expected overview of mapping of technologies for the Agri-food sector. It is based only in 16 answers, and although the work performed is a good basis, it is surprisingly low bearing in mind that there is a huge amount of DIHs listed in the European DIH catalogue. The Keyword selection process of the JCR catalogue has not been taken on the account. The mapping should be completed and iterated with a wider sample of entities, including DIHs outside the project and in other ecosystems that the project has relations with.

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Lessons learned

We suggest several ways of increasing the number of entries:

1. Improve the survey so that only relevant replies are collected
   a) Narrowing the scope so that only mature technologies are accepted
   b) Narrowing the scope away from general technologies to focus on complete robot systems
   c) Widening the scope to ensure that all relevant robots are included
   d) Asking the consortium what types of information they would like us to collect
   e) Consider the JRC keyword selection
2. Bootstrapping the catalogue entries
   a) Contact university partners asking for their literature reviews, to create an initial list of European agrifood robots
   b) Search the internet for commercially available agrifood robot
3. Dissemination and advertising
   a) Make the survey more visually attractive. Add branding
   b) Translate the survey into local languages, to remove a barrier to replying
   c) Make the catalogue publicly visible to incentivize tech developers to reply
   d) Remind partners that the survey is meant for their ecosystem to fill out, not primarily for them to fill out themselves.
   e) Presenting the catalogue at trade fairs such as GreenTech (NL) and Salon International de l'Agriculture (FR)
   f) “A serious communication effort will encourage tech providers to advertise their products on this [catalogue] site”
4. Discussing our proposed improvements with the project coordinator and agROBOfood steering group

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Methodology for version 2

From D1.1. we changed the survey to an online format to create higher attractiveness and to make it as easy as possible to fill out. Additionally, to increase the relevance of data output the scope of the technology mapping process was narrowed to robotics systems with a TRL 6+.

The following definition was displayed on the survey's frontpage and used to scope the technology entries:

Agri-food: anything involved in the processes that result in human food ready to be eaten, from soil preparation through plants (through fodder and animal care) through "harvesting" and raw preparation through cooking and shops to dining table

Robot: a machine programmed by computer, that:

Reliably* performs complex physical action in the real world

Automatically adjusts at some of its actions according to sensor input

* Reliable: can work as intended for as many hours as needed with only vary rare stops for unscheduled maintenance. In practice, this means that robots that are already commercially available or nearly so, e.g., in field trials

The Joint Research Centre (JRC) datasets (https://data.jrc.ec.europa.eu/) were investigated in the keyword selection of the survey.

To bootstrap the catalogue, extra manpower was allocated for internet search and for contact initiation with DIHs and entities beyond the agROBOfood network. These contacts were identified as knowledgeable of relevant technology systems and to encourage companies and DIHs to partake in the European catalogue. To ensure technology coverage, a high level of detail and to validate the search results all contact points were asked to participate in the survey and further distribute the survey in their network.

More action points were incorporated in the process, as described below in the walk-through of the methodology used.

Bootstrapping

During February-May 2021 DTI searched the internet for European agri-food robots and collected URLs, contact information, and some information about the types of tasks these robots could do and their capabilities. Approximately 120 robots were found that were mature enough to be included in the catalogue. This information was used to guide the survey design and to define boundaries regarding the survey scope. The technology developers were contacted directly via e-mail and invited to provide more information about their products.

The agROBOfood partners and associated members that publish papers (e.g. FhG and WUR) were asked to add robots to the catalogue from relevant, recent literature reviews.

Several universities (three Danish universities, two German, three Swedish, and one Dutch) were contacted as a mediator for further dissemination and contact initiation with emerging

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technologies developed by researcher and/or start-ups. To further the identification of start-ups besides internet search we reached out to several innovation clusters scattered across Europe and asked if they could share the survey within their network.

Furthermore, the survey was distributed in DTI's and agROBOfood's newletter with a combined potential reach of 7,000 subscribers.

New survey design

An ontology for agri-food robots was developed during May-June 2020 and used to inform the survey structure. This ontology was sent out for internal review and expanded considerably. When we received the reviewers' evaluation of D1.1, we also examined the JRC keywords, but most of them were already included in the new ontology.

A new survey push began in April 2021 with the initial results of the internet search. We decided that representing the whole ontology in survey questions would make a survey that was too heavy and take too long to fill in, so people would not do it. During the redesign phase, we realised that interested parties could collect most of this information from the robot website, once they had identified an interesting robot – and since all the technologies are supposed to be commercially available or nearly so, we could reasonably expect that all the technologies had a related webpage describing their main characteristics. We, therefore, reviewed the questions and sent them out for review again. Of course, reviewers wanted more information about their areas of interest, but we decided they could fetch most of this from the robot developers themselves when they needed this information.

We put the most important basic information on the first few pages so that partial replies would still contain the most useful information.

Survey software and trial run

We were determined to translate the survey into various European languages to remove one of the barriers that make surveys harder to fill in (see appendix B for the exported survey questions and translations). We started with English and Danish (since DTI was doing the work). This immediately raised the question of how the different-language surveys were to be combined, as the information should be pooled to create a Europe-wide picture. SurveyXact (online survey software offered by ramboll) was suggested, as this allows for identical surveys in different languages to be treated as the same survey. So, all the checkbox information can be analysed automatically, and only open-text boxes need manual attention.

Results

The results of the updated methodology can be found in D1.2. To shortly sum up the yield of the second version was the identification of 126 robots and robotics systems

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D1.1: Robotics-related Technologies Mapping for application in Agri-Food sector

WP1 – Competence Centers and Technical Expertise Management

Authors: Rune Hahn Kristensen, Bridget Hallam, Tsampikos Kounalakis

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Document Information

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Keywords	Technology Mapping, Agri-Food			

Contents

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Executive Summary

This deliverable takes the reader through our efforts to collect, analyse and map data about various available and upcoming European robotic technologies applicable to the agri-food sector, as described in Task 1.1. The intent of creating this catalogue is to promote robot deployment in agri-food and to create better solutions with improved flexibility and effectiveness, better interfacing, standardisation, etc. and all for a lower purchase price.

During the spring of 2020, a questionnaire about robotic technologies available for use in the European agri-food sector was sent out via the agROBOfood Basecamp communication portal. The aim was to categorise and map these technologies into an online catalogue to make it easy for agROBOfood hubs to know what was available and so to answer agri-food automation enquiries from their local ecosystem.

Only 16 replies were received, despite reminders. This showed that we need other methods of collecting the data and/or of persuading people to add robots to the catalogue. We suggest using students to bootstrap the process by searching the internet. This would achieve a critical mass of answers that could be catalogued and advertised, resulting in peer pressure to be included.

The replies received showed that we had succeeded in reaching outside the agROBOfood partner network, which is very positive. They also showed that we had set our scope too wide, gathering some technologies that were very generic (example: "ROS"). This catalogue is not intended for e.g. good wheels or cameras, however useful, so we decided that in the next version of this technology mapping we would limit our scope to complete robot systems that are already tested or under test -- and so available for use.

Version 2 of this deliverable is due at the end of November 2021. By that time, we aim to have a working and publicly available online catalogue populated with 100+ technologies. We will achieve this by

a. Tidying up the questionnaire to reflect our more restricted scope and increase coverage
b. Finding as many agri-food robots online as possible to form an initial population for our catalogue (bootstrapping)
c. Advertising the resulting catalogue widely
d. Visibly using this catalogue in our agri-food consultancy.

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Introduction

Task 1.1: Mapping of robotic technologies and competences in Agri-food sector
(Leader: DTI; Participants: TUD, FhG, eurecat, JR; Duration: M01-M36)

This task will map actual robotic technologies available in the Agri-Food sector, as well as potential ones from the robotic community in other sectors that could be applied within the agri- and food sector (e.g. manufacturing, including connecting to the agile manufacturing DIH network). The objective is to map relevant technologies for their maturity, expected development and potential to benefit the Agri-Food domain. Moreover, knowledge on interfacing, re-use and standardization will be included, as this is a very important issue to facilitate the creation of real and improved solutions.

A report detailing new technologies and innovations would be disseminated to DIHs and to CCs in the established network. Short version of these reports will also be posted on the project portal.

D1.1: Robotics-related Technologies Mapping for application in Agri-Food sector

This mapping process resulted in the catalogue of technologies given in Appendix A.

Scope

The scope includes robot solutions and solution elements for all aspects of agri-food from planning and production through processing, packing and transportation and up to the food being served at the table. It includes technologies that are already commercially available and less-mature technologies at all levels.

Purpose

Initially we foresee consortium partners using this catalogue to find suitable robots for their own work and suitable partners for future research collaborations. Ideally, the catalogue becomes publicly visible and its website a go-to site for information about agri-food robotics. End users, systems integrators and organisations offering consultancy can use the technology map to find the best system for their customers' needs; tech developers can use it to see what can be purchased instead of developed.

Methodology

Mapping all robot-related technologies relevant to the agri-food domain is a formidable challenge, given the extent of the domain. The approach chosen for creating an initial technology dataset was to ask partners in the agROBOfood network to complete a survey about robotic technologies that they believe to be relevant within their domain. Gathering the data in this way relies for its completeness on the fact that partners represent different regions, network nodes and parts of the value chain. This methodology inherently introduces biases towards responders fluent in English and prepared to spend time on surveys, but these biases are orthogonal to our interests and so should not affect the overall picture. We did not attempt to cover all relevant organisations but considered agROBOfood to be a sufficient network to represent the European agri-food sector.

Survey design methodology

The survey was designed by DTI with support from FhG in December 2019 and discussed with partners TUD, eurecat and JR via e-mail and online meetings in January 2020. The survey format was initially intended to be an online questionnaire. Two online platforms were tested (Google Forms and Survey Monkey) but it was challenging to find an agreeable solution where keywords and tags could easily be selected without overwhelming the user with options. In order to encourage replies, it was decided that the survey should be made to look simple to complete. PDF was selected because it could be nicely formatted and kept to two pages – one of factual questions and one of keywords with checkboxes. Free-text boxes were supplied for question answers so as not to lead respondents into particular lines of thinking. The PDF was made machine readable so that the analysis could be partially automated.

Questions, and the order these were posed in, were chosen in order to focus on the end-user needs and how technology might help solve that need. In a way, this is equivalent to how one would 'pitch' the technology to potential investors and future projects partners: *why* should this technology be promoted within the agri-food sector?

The keywords were chosen by DTI and FhG and discussed by the five partners responsible for this technology mapping deliverable. The keywords were selected so as to be relevant and comprehensive and implemented as searchable tags.

Survey distribution methodology

The survey was emailed to the 143 people on the Basecamp communication portal used by agROBOfood. In addition, some partners forwarded the survey to external contacts. The survey was sent with a request to fill in one copy of the survey for each technology to be included. The 39 agROBOfood partner organisations come from 14 countries and each partner is acting as the main contact point for agri-food robotics in its region. It was therefore expected that each partner could contribute 3-4 technologies and that 100+ replies would be easily sufficient data to create an initial map. We therefore decided to wait until a preliminary technology mapping was completed before contacting other regions.

The survey itself

The Introduction to the survey said:

> "This questionnaire is used to map robotic technologies that should be used more in the agri-food sector – from planning and production to processing and transportation – both existing technologies as well as potential technologies that can be transferred from other sectors. The intent is to create better solutions for the industry – with better interfacing, re-use & standardisation. Thank you for your input and assistance!
>
> Please fill out separate copies of this document with only **one technology** reported per saved PDF-file. Submit your contribution to the technology mapping by Apr 1 2020. Send by e-mail to **xx"**

Questions were:

- **High-level benefit to Agri-Food domain:** Outline the value added by using this technology
- **What is stopping the development?** What are the technical blockers and critical risks that prevent the development from happening today?
- **Description:** Describe the technology and its possible application. What steps are needed to validate it in the agri-food domain? If possible, provide figures for estimated timescale and investments required.
- **Current status of the technology:** Please indicate in which sectors technology is used (if outside agri-food domain). Give references to existing installations, if applicable (company, location etc).
- **Current TRL**
- **Agri-food TRL**

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- **Current providers and/or research development groups**
- **Contact details:** Can we contact you for more info? If so, provide name, organisation and e-mail.

Respondents were asked about the benefit of their system first so that the reply focused on the challenge and opportunity being solved rather than detailed engineering aspects of the technology itself.

Keywords were presented in five categories, each with subcategories:

A. Sectors
   i. Primary Production, Agriculture, Horticulture: e.g. livestock, greenhouses
   ii. Food processing, of: e.g. algae, meats
   iii. Logistics and distribution e.g. packaging, storage
   iv. Customer and market e.g. organic, transparency
B. Processes
   i. Crops and plants: e.g. fertilising, mowing, monitoring
   ii. Livestock: e.g. feeding, cleaning, milking
   iii. Primary processing: e.g. drying, freezing, canning
   iv. Secondary processing e.g. baking, fermenting
C. Products
   i. Livestock
   ii. Grains and field crops
   iii. Fruits
   iv. Vegetables
   v. Plants
   vi. Animal products
   vii. Data e.g. on growth or health
D. Technologies
   i. Robot technologies e.g. grippers, path planning, safety, data analytics
   ii. Robot type, platform e.g. drone
   iii. Software e.g. digital twinning,
E. Value drivers
   i. Nutrition
   ii. Environment
   iii. Quality
   iv. Economy
   v. Ergonomy and safety
   vi. Technology
   vii. Job creation

Each category also had an "other" subcategory where people could fill in their own classifications.

The survey as sent is attached as Appendix A in February 2020 with reminders sent in March and April 2020.

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Results and discussion

The replies are collected in Appendix A. The results are discussed in two sections – first as replies received and then the reply content is analysed. Only 16 replies were received, therefore they were analysed by hand.

Replies received

The response rate was extremely disappointing. Only two technologies were reported initially, rising to 12 after the reminder in March and 16 after a second reminder. The five partners responsible for this deliverable provided nine of the 16 replies.

Conclusions and comments

- It is obvious that we need better methods of encouraging replies – see section below.
- It is not surprising that the organisations directly involved in this technology mapping sent in the most replies.

Reply content – raw data from questions (p1)

Page one of the survey had questions expecting free-text answers. Two replies gave no information on the first side, just ticked the checkboxes on p2.

Respondent category

Fourteen of the 16 replies received were sent in by research and technology organisations (RTOs), though eight of these were reporting technologies developed by other groups. In all, 12 companies are named as tech developers and 10 of these companies are not directly connected to agROBOfood. Six replies from RTOs did not name any developer so the RTO is assumed to be the technology developer.

The final two replies were sent by CLAAS and MYX Robotics. CLAAS is represented on the agROBOfood Industrial Advisory Board. MYX robotics is a start-up not directly associated with agROBOfood.

Of the 12 companies named as tech developers, 6 are large enterprises (AEF, CLAAS, Continental, Fendt, BA systems and Veris), 2 are SMEs, 3 are start-ups and one is unknown.

No replies were received from universities.

Conclusions and comments

- We are obviously not reaching universities
- We are reaching companies of all sizes
- It is encouraging that we are reaching beyond members of agROBOfood.

Technology type

Descriptions of the 16 technologies showed that 6 were for arable (field) technologies, 2 were livestock, one was for food preparation (low-TRL), 4 were fairly generic ideas for side-stepping from the industrial domain, two were about data security and certification and the last one recommended ROS for prototyping.

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Category	Brief description	Comment
Arable (fields)	Soil sampling and monitoring	Involves different tech for different tests
	Visual weed recognition	
	Sowing and weeding	
	Tractor retrofitting	
	Mobile robot navigation	Side-stepping from cleaning to fields
	Integration of field data from many sources	Multi-layer maps
Livestock (cattle)	Robot milking	
	Calving alarm	
Food	Individualised food preparation	TRL 2-3
Generic	Mobile robot fleet control	Side-stepping from road transport?
	Logistics trolley	
	Robot manipulators	
	Error detection and recovery	Side-stepping from industry
	Standardisation of interfaces with the cloud	H2020 project
	Pre-certification of components	Regulatory process
	Using ROS	Already used in many applications

The two replies that had no content on p1 nevertheless had titles which gave their technology types as: i) robot manipulators and b) tractor retro-fitting – so one presumed generic and one arable farming.

Conclusions and comments

- We got 6+ agricultural replies to 1 food reply. This difference is statistically insignificant given our low response rate. However, the agROBOfood DIH network has many more contacts within agricultural robotics than within food. This could be a bias but may instead be an accurate reflection of reality – it is easier to design robots for the semi-structured environments of fields than for more complex environments. Also, much of the food preparation and distribution industry is automated using large machines rather than robots.
- We should consider what to do about non-technical but relevant areas such as standardisation and certification.
- We decided that we are not interested in generic technologies such as ROS (or computer vision, AI, GPS, etc.) in unspecified applications. Their use is so widespread that mapping these technologies would be meaningless. It would still be relevant and useful to create a catalogue of such experts available for consultancy, but they are too generally useful to be mapped into narrow categories.

TRL level and status

It is always difficult achieving consistency when asking people to give the TRL of their technologies. Firstly, people may not be aware of the definitions of the different levels. Secondly, academic staff tend to declare TRL *N* when their work on their robot is somewhere in the middle of the TRL *N* definition, whereas industrial staff tend to treat the TRLs as gate stages so they wait until ALL the

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defined requirements have been met. Thirdly, there is some confusion around when the definitions switch between being about single technologies to being about systems. Systems are typically built from several technologies – and even if the system is built entirely from technologies at TRL9, the system itself is still only around TRL3 to begin with (but the development phase is very accelerated compared to systems made from untested technologies).

Therefore we asked people to also give the status of their technology. Three stated that the tech was available commercially in e.g. industrial applications but said nothing about the status of the tech within agri-food. The H2020 project did not give a TRL or any status. The two replies with empty p1 obviously contained no status text. Two other replies made comments not relevant to their status. The remaining six replies gave answers meaningful to this category – and five of these answers seemed consistent with the stated TRL in as far as we could tell from the small amount of text given (for the 6th answer see * below). It is possible that some people were unclear as to what type of answer was expected here.

No.	Number at technology level …						Replies not within scope‡‡
	9: on market in agri-food	**9:** on market elsewhere	**8:** in final testing	**7:** working on site in near-final form	less than 7	not known‡	
16	3 † * ⊗	1**	1⊗⊗	1††	4	3	3

‡ Two responses had no information on p1. Two other responses gave no TRL level but it was obvious from the rest of the content that the TRL was below 7.

‡‡ Three survey responses were considered out of scope. Two involved standardisation and certification so are not themselves technologies, but they are definitely relevant to the agri-food robotics field. The third response suggested ROS as a robot technology but this was felt to be too generic to be relevant in a technology mapping.

† An autonomous sowing and weeding robot from FarmDroid, Denmark, tested over 8 years on their own fields and now 2-3 years on customer fields.

* This is a trolley that autonomously transports items without needing ground infrastructure (from Baylo and BA systèmes, France). Commercially available so TRL9 -- but also written as still needing: a) to be able to compute its localization in any place, b) to be able to move in safe conditions, c) to be able to communicate with WMSs. So the real TRL is debatable.

⊗ Robot milking, well established in livestock farming

⊗⊗ A calving alarm which is commercially available but still under test, TRL 8-9. If we compare this with * above, we can see how inconsistent peoples' estimates of TRL can be.

** A set of soil sampling and analysis tools from the American company Veris via BioSense, Serbia.

†† Software integration from multiple sources creating multilayer field maps from MYX robotics, about to start trials.

Conclusions and comments

- We decided that we are not interested in technologies existing only at very low TRLs. The DoA says that "*This task will map actual robotic technologies available in the Agri-Food sector, as well as potential ones from the robotic community in other sectors that could be applied within the agri-and food sector*". Low-TRL technologies are not "available". More is written about this in the section on improvements for Version 2.

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Benefits to agri-food robotics

Five replies gave benefits that were a summary of the task. Of the remaining seven (two of the 14 replies were empty):

- Two mentioned providing the farmer with better data
- Three mentioned increasing productivity
- Two mentioned reduced cost
- Four mentioned reducing labour requirements, one of these also mentioned reducing arduous work
- One mentioned reducing soil compaction
- One mentioned reducing birthing risks for cattle
- One (about error reduction) mentioned reduced maintenance requirements.

Barriers to development

Three responses left the "Barriers" text field empty and another four felt that they did not have barriers, development was proceeding fine. Two said that safety standards were problematic and one mentioned the high standards of cleaning (of the machine) required to ensure food safety. One suggested that power and robustness requirements were a barrier. Two mentioned price, feeling that their business case was very marginal. One wrote that the seasonal nature of their work meant that their robot system would have to be given other tasks to make a viable business case. Two suggested that farmers were not aware of the capabilities of new technologies so would not think of investing. One felt that significant training was needed to use the robot efficiently. One suggested that industrial support could help agri-food applications.

Conclusions

- Only half the respondents felt that they faced barriers to their technology's development, which is encouraging. The barriers faced by the rest are very varied.

Reply content – raw data from questionnaire “tags” (p2)

The response regarding ROS clicked all main headings and no subheadings across p2 A-D except for "other", A: customer, market and D:robot type, platform.

A. Sectors

All 16 replies checked something in the ***Sectors*** section and no-one used "other”, so it seems as though ***Sectors*** contained a good set of categories. It is interesting that so many categories are used – some of this is due to our getting replies about quite different types of robots (which is good) but some was due to the more generic technologies being relevant to all sectors, so the sector categories are not able to distinguish between the technologies. It could be seen that some people clicked on the category heading if they clicked some subcategory where other people did not. The more generic responses tended to tick main categories without necessarily ticking any subcategories.

Figure 1 shows the distribution of responses according to ***Sectors***. The technology development of our respondents currently revolves around primary production (agriculture), food processing and logistic operations.

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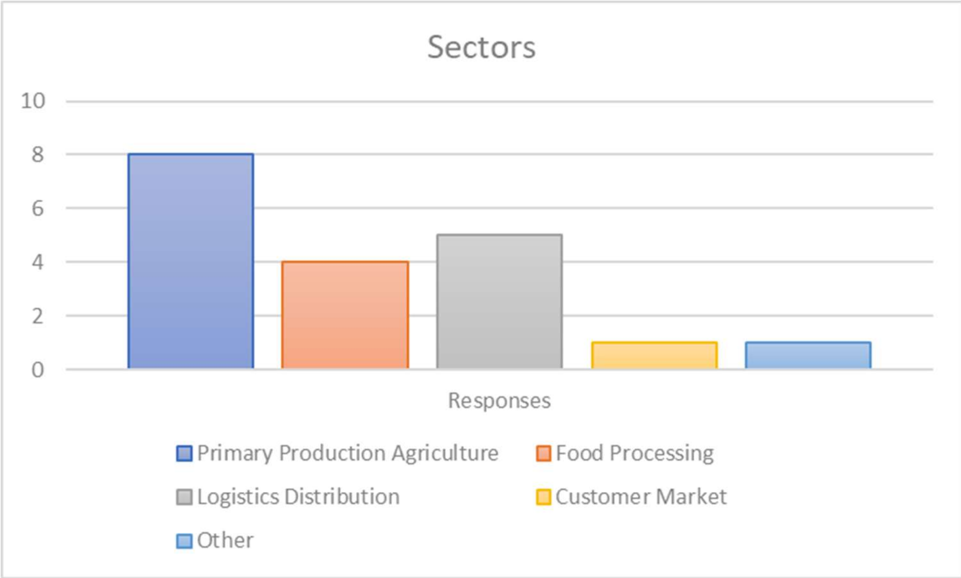

Figure 1: Responses for the primary **Sectors** *of the survey.*

Figure 2 provides a clearer view of the subdivisions within the main ***Sectors*** categories. As can be seen, within primary production (green boxes), fields and greenhouses are the main environments for upcoming robotic applications, where transportation will be the main logistics application area. For food processing and customer/market, the samples consist of single entries and therefore we consider we have insufficient data for analysis.

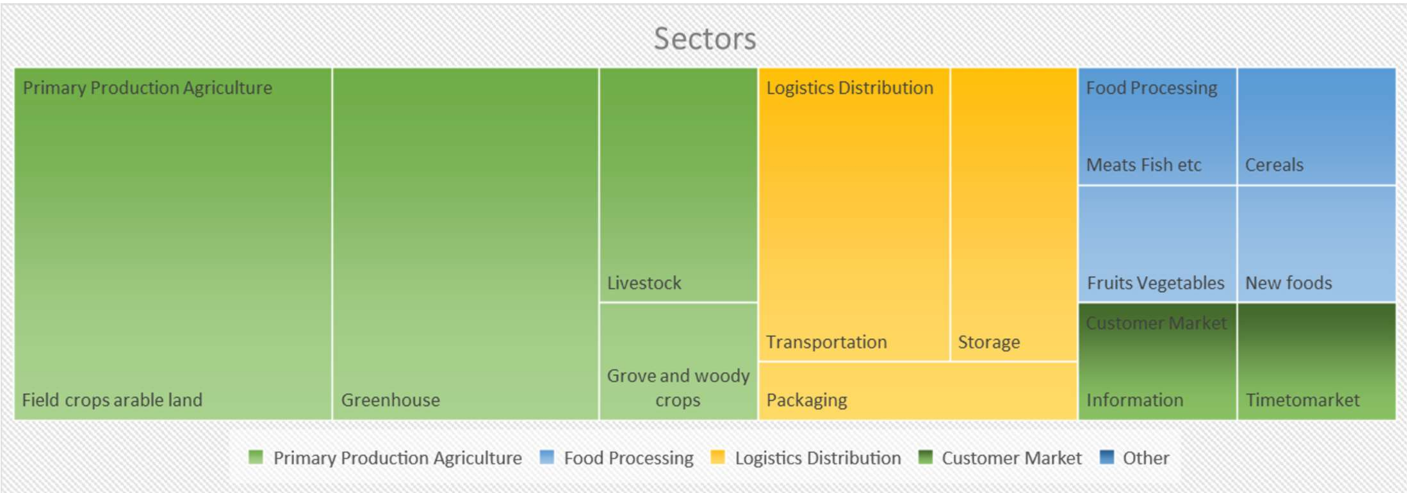

Figure 2: Map of the individual responses provided in the **Sectors** *section of the survey*

B. Processes

Two replies did not check anything in the ***Processes*** section. Many of the subcategories were left blank by everyone, especially within *Primary Processing*. This suggests that these subcategories need rethinking, or that it is very hard to map technologies to specific processes. For example, generic technologies such as autonomous navigation can be used for many of these processes so it is very hard to decide which of the defined categories and subcategories to tick, and therefore the answers were vague and inconsistent.

As seen in Figure 3, the category of *Crops, Plants* is the most popular within ***Processes***, while there where few responses in the other categories. In the detailed responses within those categories (see Figure 4), the subcategories chosen for *Crops, Plants* are varied. Most of the responses tick weed spraying and preparation for seeding. We can also see that there was a smaller interest, i.e., three responses per subcategory, in fertilization, monitoring and harvesting. The rest of the responses

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shown in Figure 4 consist of one entry each and therefore it is unsafe to conclude any real interest in those fields.

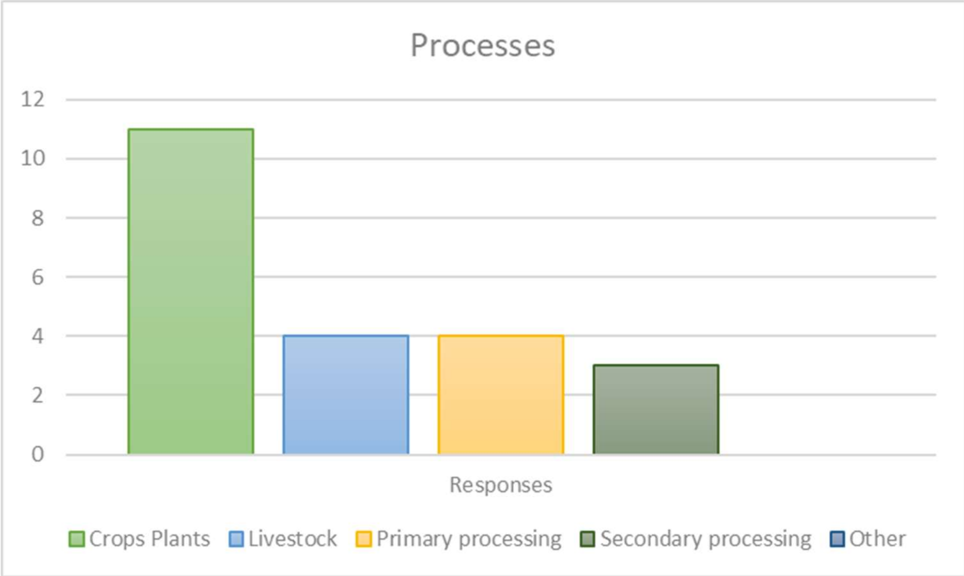

Figure 3: Responses for the primary **Processes** *of the survey.*

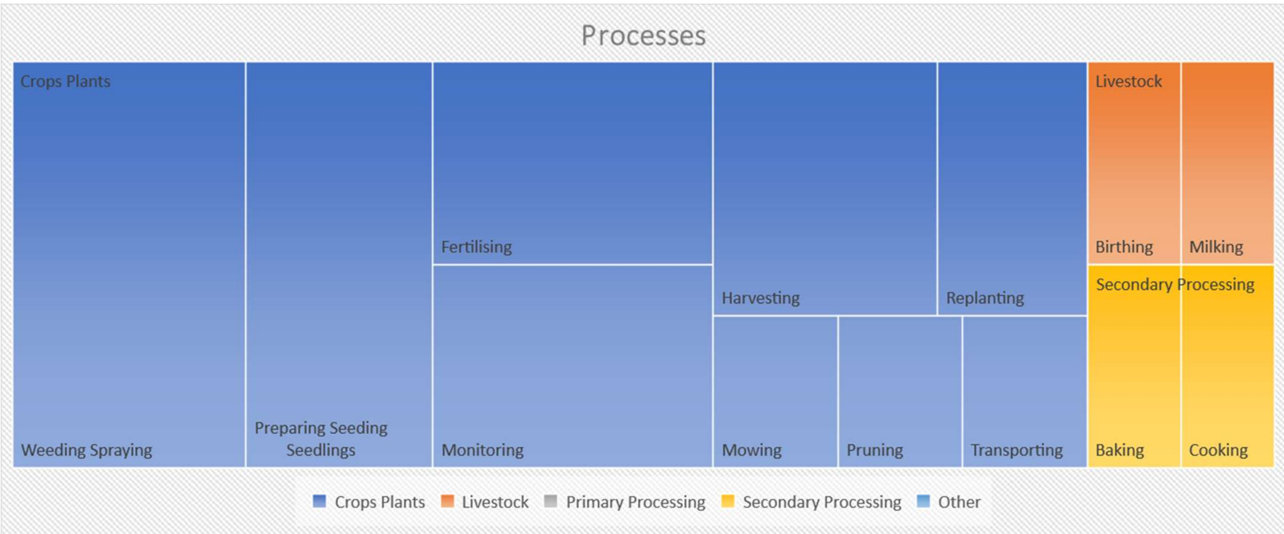

Figure 4: Map of the individual responses provided in the Processes section of the survey

C. Products

We have identified that some of the categories within the ***Products*** section might be ambiguous, in that all "grain and field crop" examples are grains and a "vegetables" category also exists, also the very general heading "plants". This suggests that the many who clicked on the main categories "fruits", "vegetables" and "plants" without clicking on the subcategories may just have been covering all the options. These categories need rethinking and will be amended in our future version.

It is debatable whether flower crops such as roses should count as agri-food. It depends on whether we consider agri-food to be defined as including anything related to either agriculture or food, or just things in the intersection. Or a third option e.g. anything on any direct route from plant growth to food on the table, but not including anything not on this route (e.g. growing non-edible flowers).

Three replies did not check anything in this section; however, this was the section with the most participation at the category level. Figure 5 shows that most of the technologies relate to products addressing grains and field crops, fruits, vegetables, and general plants. The high numbers (43

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categories ticked from 16 responses) could be due to the technologies being useful in several of the different categories but could instead be duplications of the same information due to the ambiguity that we described above.

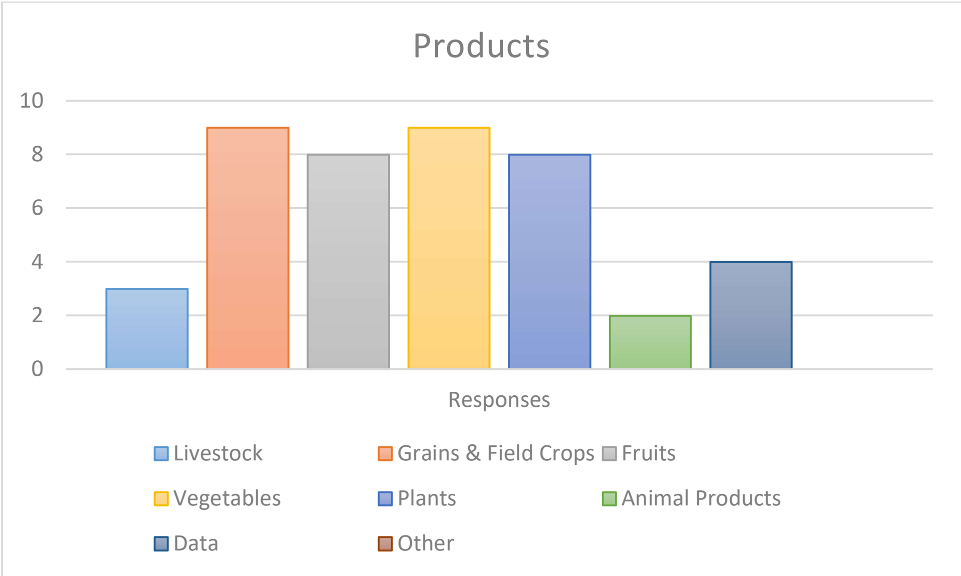

Figure 5: Responses for the primary **Products** *of the survey.*

Regarding the individual answers for ***Products***, no safe conclusions can be drawn here. Few of the respondents gave detailed answers and therefore the largest subcategories (see Figure 6) only have two answers.

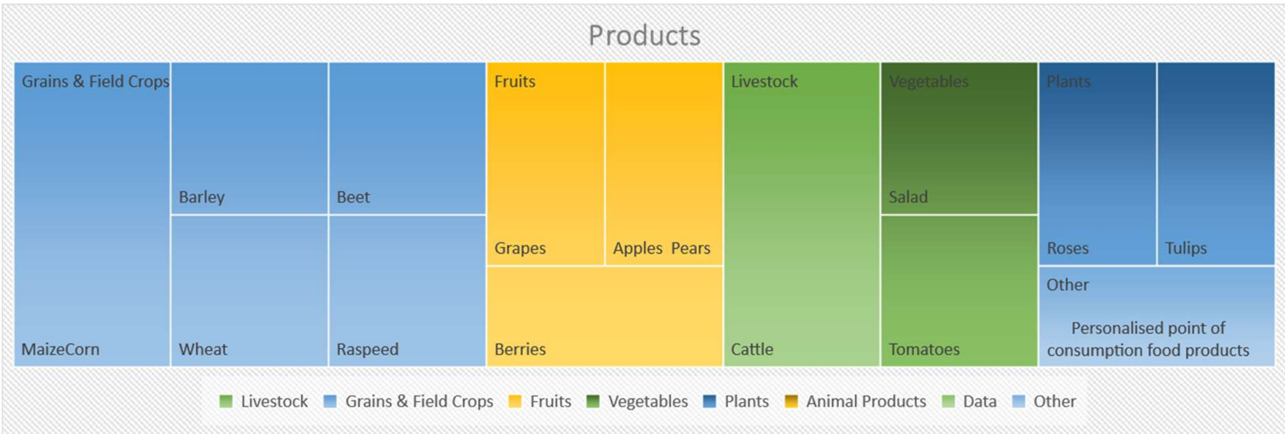

Figure 6: Map of the individual responses provided in the **Products** *section of the survey*

D. Technologies

Two replies did not check anything in this section; however the rest of the replies were well distributed, indicating that the categories chosen were good. Three uses of the "other" category suggests that maybe the list of subcategories should be expanded.

Figure 7 shows the responses given in the main categories of the ***Technologies*** section. It is surprising that only 10 of the 16 felt that their technology fitted under the category *Robot Technologies* and only 7 – less than half – had *Software.* Since our mapping and therefore our survey is supposed to be about agri-food robotics and the categories in this ***Technologies*** section were general enough to include all types of robotics, it seems that our scope was too wide and our survey attracted non-robotic technologies.

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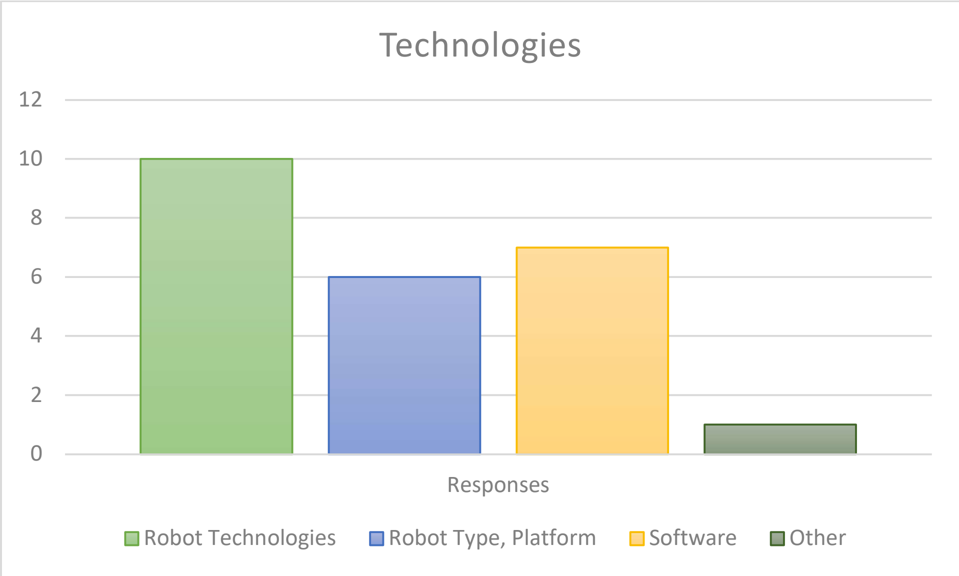

Figure 7: Responses for the primary **Technologies** *of the survey.*

Participants were very detailed in their overall answers so we know something about the technologies they work with and know (bearing in mind the data set is limited). As seen in Figure 8, most technologies include navigation, control and path planning, while fewer of the technologies in our replies included vision and gripper technologies. Respondents were more likely to use mobile robots without manipulation and drones. Integration software is the most common agri-food software technology, while other identified software is not as strong.

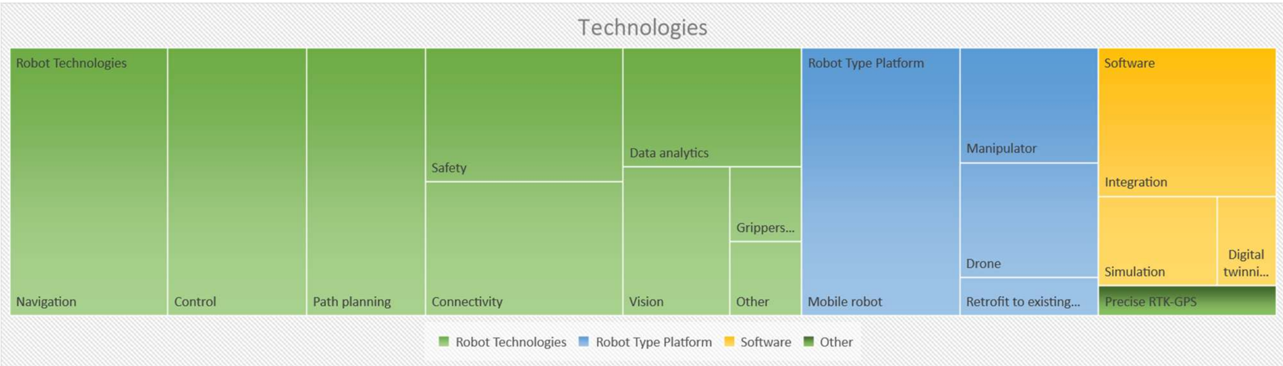

Figure 8: Map of the individual responses provided in the Technologies section of the survey

E. Value Drivers

Three replies did not check anything in this section, but the rest were well distributed. As can be seen from Figure 9, most respondents want to be at the forefront of technology development. However, participants also identified that economy and ergonomic safety are very important drivers for current and future robotics solutions. The one "other" category mentioned by a respondent is waste reduction.

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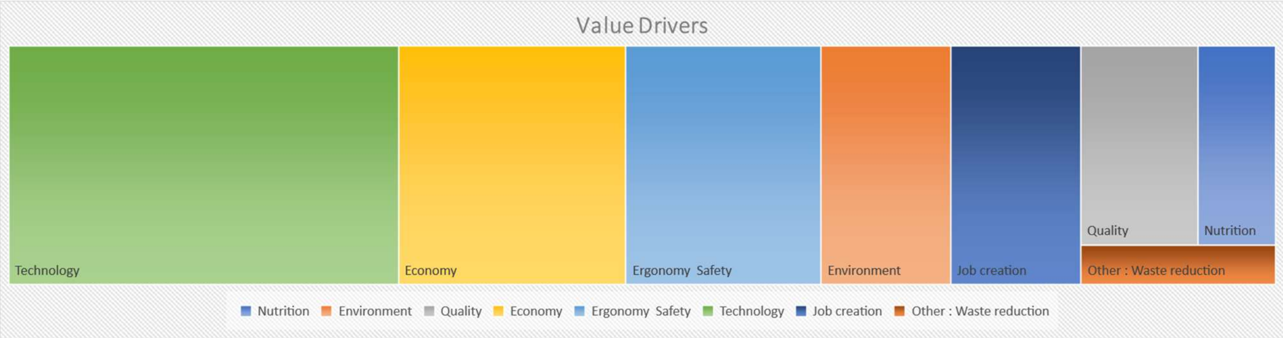

Figure 9: Map of the individual responses provided in the **Value Drivers** *section of the survey*

Technology Mapping

It was felt that we had received too little relevant data to be able to map any relationships between the technologies, except in the basic form given in the graphics above. We therefore decided to treat this round as a trial run – we have learned a lot that will help us to achieve more responses with higher relevance in the next phase of this process (see below).

Comments

- It would be helpful to limit the scope and remove some of the fuzzier edges of the data to be mapped.

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Conclusions

We need to get many more replies if the survey is to reflect the current state of European agri-food robots with any level of accuracy. Until we get sufficient replies, any catalogue we make will be so sparse as to be useless. It is obvious that the various partners in agROBOfood have not really got behind this technology mapping process. With 39 actual partners from 14 countries, each representing a local ecosystem of organisations involved in agri-food, we expected something like 120 replies (3-4 per partner) initially. We need some way of getting the consortium partners to contribute their local technologies. In particular, we need to make contact with the universities and hook into their research abilities. We recently (15th May) discovered that Fountas *et al* have just published a review of 153 references about field robots[1] as part of the agROBOfood project – if they had communicated their findings to us then we would have had sufficient technologies in our database to have mapped European field robots. Maybe other agROBOfood universities have also conducted literature reviews that we did not find out about.

Improving the survey and its distribution and emphasising the benefits of survey completion are obvious changes that could be made. Non-survey methods should also be considered. We strongly believe that if we can get a critical mass of agri-food robots in a catalogue that is ***visible*** to the agri-food community, then the catalogue will be self-perpetuating – that organisations will wish to advertise their technologies on the agROBOfood scene. We had assumed that making the catalogue visible would come after we had collected the data – but maybe we can't get sufficient replies to record until the catalogue is more visible. Bootstrapping the initial information gathering by e.g. internet searches could help by creating a sufficiently comprehensive catalogue to be made visible – which will encourage the desire to be represented.

We have already tried to make the process of responding ***easy*** by providing a clickable pdf file, but maybe using online survey tools such as those listed on https://www.capterra.com/sem-compare/survey-software would be easier for people. Providing a local-language introduction could also encourage replies.

We need to make the idea of responding ***more attractive*****.** We intend talking to the project officer about how to achieve this, implementing the ideas described below and getting a professional advertiser/sales person involved (ideally a person from one of the companies in agROBOfood). Outsourcing or even crowdsourcing the technology catalogue relies on adequate outreach and coverage of the value chain.

[1] Fountas, S., Mylonas, N., Malounas, I., Rodias, E., Hellmann Santos, C., & Pekkeriet, E. (2020). Agricultural Robotics for Field Operations. *Sensors*, *20*(9), 2672.

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Improvements for D1.2

This section discusses ways to avoid the problems found during this first attempt at technology mapping and ends with a proposed improved methodology for creating version 2 of this deliverable "D1.2 Robotics-related Technologies in the Agri-Food sector (an update) and additional potential for innovation" due in M30 (Nov 2021). We want our catalogue to be useful so that the results become the go-to place for people such as end users and systems integrators looking for specific technologies to use, for people such as researchers wanting development partners, or for politicians and the general public wishing to know what is happening in their area.

The most important point is to collect more of the information that we really want. Since replies to a questionnaire are scarce, then other methods are needed. We will send explicit requests to agROBOfood universities to ask about relevant literature reviews and if they can help with extracting the information we need from these. Collecting data about commercial robots direct from the internet would be another way of bootstrapping information. Once sufficient information is received, then the catalogue can be made public. If the catalogue is visible and is used, then technology owners will be incentivized to get their tech included. The survey itself should be redesigned somewhat to remove ambiguities and collect the information needed.

Maybe we should ask the consortium and their ecosystem members what types of information they would like the catalogue to obtain, what would be useful to them?

Collecting the information needed

Increasing the contribution from agROBOfood partners

The poor response may be partly because agROBOfood has already sent out several surveys and people are tired of replying, but it is more likely that they just don't see the benefit that this survey could bring. Admittedly the main benefits (more information about what is already available, development support, increased sales, etc.) only appear when responses are publicly visible and fairly comprehensive.

Perhaps part of the problem is that many partners e.g. the RTOs are enablers, ready to help other organisations to develop agri-food technologies but not actually owners of IP in agri-food tech themselves. Maybe we need to point out that the survey was not for partners as organisations, but for partners **as hubs for their local agri-food ecosystem.** Since partners are a gateway to this ecosystem, they should consider themselves responsible for passing the survey on to other actors in their ecosystems.

Narrowing the scope

We feel that focussing the process by narrowing the scope will both allow us to focus our efforts for greater efficiency and make the results more meaningful. We therefore intend restricting requests to **robot systems** that already exist in final or near-final form and are either a) already commercially available or b) under test in the real environment or about to be so and expect to be placed on the market within the next 3 years. This equates to the robot system having completed TRL 7 or better. This brings us closer to the original task description, where the mapping was for "available" technologies. It also has the advantage that the focus of our request is more obviously on commercial and near-commercial products which are already available to be used for supplying the agri-food industry or in innovation research. These are the robots most likely to be deployed and create value for their companies and European society.

Note that we intend requesting information only on complete robot systems, not robot technologies, in the next round of this Task. Many technologies e.g. a mobile robot base are useful in several different applications, which means that to map them properly they would appear in many places which would make the catalogue messy. By contrast, complete systems have only a few applications so are easier to map – even when they are comprised of several interesting technologies. This means that the survey must be adapted to a) give the new instructions and b) allow space for different aspects of the robot system to be described, so that technologies are still represented when they are part of a functioning robot system.

Bootstrapping

We could bootstrap the process by employing students to extract information from relevant recent literature reviews and to search websites to find robots in the European agri-food sector. All robots that are commercially available are visible on the internet and many research robots as well. We would collect as much of the required information as possible directly from the internet and then we could call the developer/sales people for the final details. Student labour is cheap, so this would not take a lot from the agROBOfood budget. Once a critical mass is achieved, we can advertise the catalogue and it will become more interesting for people to ensure that their robots are in it.

Dissemination and advertising

We need to make the technology mapping results very visible, if people are to use the catalogue. The introduction to the survey could point out that being in the catalogue is a form of free advertising for both commercial and research robots – though this argument only works if the catalogue is accessible. The catalogue should be made available online and exhibited: both at public-accessible partner sites and at suitable events e.g. agricultural technology trade fairs such as GreenTech in the Netherlands and Salon International de l'Agriculture in France. Most of the exhibitors and attendees at such events are our target respondents. The questionnaire could be made directly available at the event itself as well as via the link given on the posters. The website could also offer the opportunity for people to leave reviews of robots that they have used.

Improving the survey itself

Before we make any major push for more information, we need to upgrade the survey to incorporate the new ideas outlined above and mitigate some of the problems we encountered.

Questions (currently on p1)

The initial questions will need to be expanded to collect sufficient data on robot **technologies** while asking only about complete **robot systems**. We need to define our scope such that e.g. a vision system does not count until it is part of a robot performing an agri-food task. A second page of questions will almost certainly be needed – maybe one side could be dedicated to the robot system and the second side to the contributing technologies.

Note that it is vitally important that we decide on the information to be mapped and the mapping process before making the final choice about questions. It would be too embarrassing to collect lots of data and still be unable to map the tech and make the catalogue useful due to missing critical pieces of information or having questions which were ambiguous.

The system page should ask for:

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- robot system name, URL, main task(s)
- geographical location of the robot **system**'s "home"
- system developer name and contact details for technical information
- distributor (local availability) information
- the main benefits the robot offers to the agri-food sector
- the barriers that hinder its deployment / development
- a brief technical/scientific description
- a paragraph of advertising text
- a list of the special abilities/skills exhibited by the robot
- a list of the main technologies that make this system special

The technologies page should ask about the component technologies e.g. actuation, perception, AI. Most of this tech will be listed in the keywords, but only in terms of its existence or not. So probably the tech questions should come after the keyword checklists. Questions should include:

- Name of each major component
- Tech supplier (or main researcher) for each major component
- Main reason for choosing this component – its advantages over its rivals

Clickable categories (currently on p2)

Analysis of the categories used shows that:

- Some categories are confusing. For instance under "B. Products" there are no root vegetable examples under "field crops", but "vegetables" is a separate category later
- There are categories missing: e.g. a major heading for logistics under "C: Processes"
- There is considerable overlap between "A. Sectors" and "B. Processes"
- Some of the processes (e.g. canning) are generally automated by large machines instead of robots
- The level of detail under "primary processing" is huge compared to "secondary processing"

In particular, we focussed on agricultural robots – our experience regarding food preparation robots is a lot more limited. Part of this bias is because food tends to be produced in huge quantities under circumstances where hard (fixed) automation is more appropriate than robot solutions – but most of it is due to the primarily agricultural interests of most agROBOfood partners.

We suggest making a serious attempt to create a comprehensive ontology for agri-food robotics to inform the questionnaire categories and also to be used for catalogue organisation.

Methodology for D1.2

Following the significant disappointment in creating an initial catalogue for version D1.1, we decided to start working towards the updated D1.2 already.

We are currently working on improving the categories and keywords for an updated survey. We intend asking partners what information they want to be collected and what they will use it for. Only actually useful information is worth collecting. Before opening the new survey to the public, we will employ students to perform internet searches and find at least 80 European robot systems in agri-food. The students will fill in survey forms for each, reporting any problems and making suggestions in an ongoing survey refinement process.

We will also consider if the data collected should be analysed and organised in any way more than just using keywords and making the catalogue searchable online. These decisions about the information to be collected could be made in parallel with any bootstrapping process as missing information can be re-searched at that stage without embarrassment.

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After the trial run of the questions / categories via the bootstrapping process, the questionnaire will be formatted, branded and generally made attractive, in both a web-based and a "paper" online version. The introduction / instructions will be distributed through the local agri-food ecosystems.

The questionnaire will be sent out as soon as it is ready, to maximise the time available for responses to be received. It will be advertised on the project website and sent to all agROBOfood partners with instructions to distribute it to ALL agri-food robotics stakeholders in their area. A serious communication effort will encourage tech providers to advertise their products on this site. Continuously updated information about new additions and running totals of answers from various regions will add visible movement to the website.

Two major pushes to obtain information will be made: one soon after the new questionnaire is ready and another 6-8 weeks before the D1.2 deadline on Nov 30th, 2021.

By the deadline, we expect to have over 150 robot systems represented in a catalogue that is highly visible on the project website and exhibited at core partner sites.

We wish to start this whole process by discussing this revised methodology with the project coordinator and agROBOfood steering group. The methodology proposed above will be adapted according to their suggestions.

END OF DOCUMENT

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Appendix A

Replies to the survey described in this report D1.1 resulted in the following catalogue of technologies:

1. Data exchange (AEF, Norbert Schlingmann)
2. Personalized on demand food (VTT, Nesli Sözer)
3. Camera-based weed recognition (DTI, Riccardo Besana)
4. Robot fleets (DTI, Riccardo Besana)
5. Error recovery (FhG, Christoph Hellmann)
6. Navigation (FhG, Christoph Hellmann)
7. ROS (FhG, Christoph Hellmann)
8. Sensors for autonomous mobile robot (CLAAS E-Systems, Thilo Steckel)
9. Mobile platform (Irstea, Christophe Debain)
10. Robot manipulators (Eurecat, Ferran Roure)
11. Tractor retrofitting (Eurecat, Ferran Roure)
12. Soil sampling & analysis (BIOS, Goran Kitic)
13. Software integration (MyxRobotics, Krasimira Shindarova)
14. Autonomous sowing & weeding (Farmdroid)
15. Calving Sensor (TSSG, Christine O'Meara)
16. Robotic milking (TSSG, Christine O'Meara)

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agROBOfood – Technology Mapping

Introduction:

This questionnaire is used to map robotic technologies that should be used more in the agri-food sector – from planning and production to processing and transportation – both existing technologies as well as potential technologies that can be transferred from other sectors. The intent is to create better solutions for the industry – with better interfacing, re-use & standardisation. Thank you for your input and assistance!

Please fill out separate copies of this document with only **one technology** reported per saved PDF-file.
Submit your contribution to the technology mapping by Apr 1 2020. Send by e-mail to rhk@dti.dk

High-level benefit to Agri-Food domain:
Outline the value added by using this technology

Exchange of data from machine to machine and from machine to cloud is necessary. Standards have to be used. Task data and telemetry data could be exchanged. Ag industry is working on common standards although companies using their own solution. EU project ATLAS is defining a standard for cloud communication

What is stopping the development?
What are the technical blockers and critical risks that prevent the development from happening today?

Use specific approach and none understanding that security and safety have to be integarted to protect machine for unintended access

Description:
Describe the technology and its possible application. What steps are needed to validate it in the agri-food domain? If possible, provide figures for estimated timescale and investments required.

Understanding that interfaces to contect existing clouds are necessary. Benefit for customers to get data from different multibranded machines.

Current status of the technology:
Please indicate in which sectors technology is used (if outside agri-food domain). Give references to existing installations, if applicable (company, location etc).

Current TRL:
TRL1 = Basic principles observed
TRL9 = Actual system proven

Agri-Food TRL:

Current providers and/or **Developer/research groups:**

Contact details
Can we contact you for more info? If so, provide name, organisation and e-mail.

AEF e.V.
ATLAS project: https://www.atlas-h2020.eu/

Date / Version No.
24.02.2020

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Searchable Keywords & Tags for Classification

A. Sectors

- [ ] **Primary Production, Agriculture, Horticulture:**
  - [ ] Greenhouse
  - [ ] Field crops (arable land)
  - [ ] Grove and woody crops
  - [ ] Aquaculture
  - [ ] Fungiculture
  - [ ] Algaculture
  - [ ] Livestock
- [ ] **Food Processing:**
  - [ ] Meats, Fish, etc
  - [ ] Fruits, Vegetables
  - [ ] Cereals
  - [ ] Fungus
  - [ ] Algae
  - [ ] New foods
- [ ] **Logistics, Distribution**:
  - [ ] Packaging
  - [x] Transportation
  - [ ] Storage
- [ ] **Customer, Market:**
  - [x] Information
  - [ ] Transparency
  - [ ] Time-to-market
  - [ ] Organic
- [ ] **Other:**

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Instruction:

Please select as many keywords and detailed tags as possible; it will make it easier for others to locate this suggestion when searching.

B. Processes

- [x] **Crops, Plants:**
  - [ ] Preparing, Seeding, Seedlings
  - [x] Replanting
  - [ ] Watering
  - [x] Fertilising
  - [ ] Pollinating
  - [x] Weeding, Spraying
  - [ ] Mowing
  - [ ] Pruning
  - [x] Monitoring
  - [x] Harvesting
  - [ ] Transporting
- [ ] **Livestock:**
  - [ ] Insemination
  - [ ] Birthing
  - [ ] Feeding
  - [ ] Cleaning
  - [ ] Milking
  - [ ] Shearing
  - [ ] Searching
  - [ ] Vaccinating
  - [ ] Transporting
- [ ] **Primary Processing**:
  - [ ] Drying
  - [ ] Threshing, Winnowing
  - [ ] Milling
  - [ ] Shelling
  - [ ] Butchering
  - [ ] Deboning
  - [ ] Cutting
  - [ ] Freezing
  - [ ] Smoking
  - [ ] Pressing, Extracting
  - [ ] Filtering
  - [ ] Canning
  - [ ] Homogenizing
  - [ ] Pasteurizing
  - [ ] Packaging
  - [ ] Transporting
- [ ] **Secondary Processing:**
  - [ ] Comminution
  - [ ] Fermenting
  - [ ] Baking
  - [ ] Cooking
  - [ ] Transporting
- [ ] **Other:**

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C. Products

- [ ] **Livestock:**
  - [ ] Cattle
  - [ ] Poultry
  - [ ] Pig
  - [ ] Goat
  - [ ] Sheep
  - [ ] Fish
- [ ] **Grains & Field Crops:**
  - [x] Barley
  - [x] Wheat
  - [x] Maize/Corn
  - [ ] ______________
- [ ] **Fruits:**
  - [ ] Grapes
  - [ ] Apples & Pears
  - [ ] Berries
  - [ ] ______________
- [ ] **Vegetables:**
  - [ ] Salad
  - [ ] Tomatoes
  - [ ] ______________
- [ ] **Plants:**
  - [ ] Roses
  - [ ] Tulips
  - [ ] ______________
- [ ] **Animal Products:**
  - [ ] Milk
  - [ ] Meat
  - [ ] Eggs
  - [ ] ______________
- [ ] **"Data":**
  - [ ] Growth info
  - [ ] Health info
  - [ ] ______________
- [ ] **Other:**

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D. Technologies

- [ ] **Robot Technologies**
  - [ ] Vision
  - [ ] Control
  - [ ] Path planning
  - [x] Navigation
  - [x] Safety
  - [x] Connectivity
  - [x] Data analytics
  - [ ] Grippers/Grasping
  - [ ] ______________
- [ ] **Robot Type, Platform:**
  - [ ] Mobile robot
  - [ ] Manipulator
  - [ ] Drone
  - [ ] Retrofit to existing vehicle
  - [ ] ______________
- [ ] **Software:**
  - [ ] Digital twinning
  - [x] Simulation
  - [x] Integration
  - [ ] ______________
- [ ] **Other:**

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E. Value Drivers

- [ ] **Nutrition**
  (more food available)
- [ ] **Environment**
  (climate, organic, **etc)**
- [x] **Quality**
  (higher quality products for the customers)
- [x] **Economy**
  (less costly products for the customer, higher revenue for the producer)
- [x] **Ergonomy & Safety**
  (less manual work required, improved work-environment)
- [x] **Technology**
  (to be in the front line within technology development)
- [ ] **Job creation**
  (more jobs, keeping jobs in Europe)
- [ ] **Other:**

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agROBOfood – Technology Mapping

Introduction:

This questionnaire is used to map robotic technologies that should be used more in the agri-food sector – from planning and production to processing and transportation – both existing technologies as well as potential technologies that can be transferred from other sectors. The intent is to create better solutions for the industry – with better interfacing, re-use & standardisation. Thank you for your input and assistance!

Please fill out separate copies of this document with only one technology reported per saved PDF-file.
Submit your contribution to the technology mapping by Apr 1 2020. Send by e-mail to rhk@dti.dk

High-level benefit to Agri-Food domain:
Outline the value added by using this technology

Personalized on demand food production

What is stopping the development?
What are the technical blockers and critical risks that prevent the development from happening today?

Not all the food ingredients and/or recipes can accommodate instant, on demand food production. The auxiliary unit operations in a typical food processing line is rather time consuming which restricts this type of on-demand food manufacturing machines where the consumer wishes to have rather short waiting time (eg 2-3 min of preparation time). Also food safety, cleaning and maintenance of these kind of food production machines should be specifically considered.

Description:
Describe the technology and its possible application. What steps are needed to validate it in the agri-food domain? If possible, provide figures for estimated timescale and investments required.

A food manufacturing hub starting from scratch and shelf stable ingredients (ie flour, protein powders) where macronutrients (eg protein, dietary fibre, carbohydrates) but also micronutrients (eg vitamins) can be delivered based on invidual needs and preferences of the consumer. These kind of manufacturing machines can for example be placed in retail environment, hospitals, schools, airports etc (more info https://www.youtube.com/watch?v=zrPvfqRw034).

Current status of the technology:
Please indicate in which sectors technology is used (if outside agri-food domain). Give references to existing installations, if applicable (company, location etc).

These kind of manufacturing machines can for example be placed in retail environment, hospitals, schools, airports etc (more info https://www.youtube.com/watch?v=zrPvfqRw034).

Current TRL:
TRL1 = Basic principles observed
TRL9 = Actual system proven

TRL 5/6

Agri-Food TRL:

Current providers and/or Developer/research groups:

VTT Technical Research Centre of Finland Ltd

Contact details
Can we contact you for more info? If so, provide name, organisation and e-mail.

Nesli Sözer (research professor, VTT Technical Research Centre of Finland Ltd, nesli.sozer@vtt.fi)

Date / Version No.
03.03.2020

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825395

Searchable Keywords & Tags for Classification

A. Sectors

- [ ] Primary Production, Agriculture, Horticulture:
  - [ ] Greenhouse
  - [ ] Field crops (arable land)
  - [ ] Grove and woody crops
  - [ ] Aquaculture
  - [ ] Fungiculture
  - [ ] Algaculture
  - [ ] Livestock
- [ ] Food Processing:
  - [ ] Meats, Fish, etc
  - [ ] Fruits, Vegetables
  - [ ] Cereals
  - [ ] Fungus
  - [ ] Algae
  - [x] New foods
- [ ] Logistics, Distribution:
  - [ ] Packaging
  - [ ] Transportation
  - [ ] Storage
- [ ] Customer, Market:
  - [ ] Information
  - [ ] Transparency
  - [ ] Time-to-market
  - [ ] Organic

- [ ] Other:

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Instruction:

Please select as many keywords and detailed tags as possible; it will make it easier for others to locate this suggestion when searching.

B. Processes

- [ ] Crops, Plants:
  - [ ] Preparing, Seeding, Seedlings
  - [ ] Replanting
  - [ ] Watering
  - [ ] Fertilising
  - [ ] Pollinating
  - [ ] Weeding, Spraying
  - [ ] Mowing
  - [ ] Pruning
  - [ ] Monitoring
  - [ ] Harvesting
  - [ ] Transporting
- [ ] Livestock:
  - [ ] Insemination
  - [ ] Birthing
  - [ ] Feeding
  - [ ] Cleaning
  - [ ] Milking
  - [ ] Shearing
  - [ ] Searching
  - [ ] Vaccinating
  - [ ] Transporting
- [ ] Primary Processing:
  - [ ] Drying
  - [ ] Threshing, Winnowing
  - [ ] Milling
  - [ ] Shelling
  - [ ] Butchering
  - [ ] Deboning
  - [ ] Cutting
  - [ ] Freezing
  - [ ] Smoking
  - [ ] Pressing, Extracting
  - [ ] Filtering
  - [ ] Canning
  - [ ] Homogenizing
  - [ ] Pasteurizing
  - [ ] Packaging
  - [ ] Transporting
- [ ] Secondary Processing:
  - [ ] Comminution
  - [ ] Fermenting
  - [x] Baking
  - [x] Cooking
  - [ ] Transporting
- [ ] Other:

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C. Products

- [ ] Livestock:
  - [ ] Cattle
  - [ ] Poultry
  - [ ] Pig
  - [ ] Goat
  - [ ] Sheep
  - [ ] Fish
- [ ] Grains & Field Crops:
  - [ ] Barley
  - [ ] Wheat
  - [ ] Maize/Corn
  - [ ] ______________
- [ ] Fruits:
  - [ ] Grapes
  - [ ] Apples & Pears
  - [ ] Berries
  - [ ] ______________
- [ ] Vegetables:
  - [ ] Salad
  - [ ] Tomatoes
  - [ ] ______________
- [ ] Plants:
  - [ ] Roses
  - [ ] Tulips
  - [ ] ______________
- [ ] Animal Products:
  - [ ] Milk
  - [ ] Meat
  - [ ] Eggs
  - [ ] ______________
- [ ] "Data":
  - [ ] Growth info
  - [ ] Health info
  - [ ] ______________

- [ ] Other:

Personalized point of consumption food products

D. Technologies

- [ ] Robot Technologies
  - [ ] Vision
  - [x] Control
  - [ ] Path planning
  - [ ] Navigation
  - [ ] Safety
  - [x] Connectivity
  - [x] Data analytics
  - [x] Grippers/Grasping
  - [ ] ______________
- [ ] Robot Type, Platform:
  - [ ] Mobile robot
  - [ ] Manipulator
  - [ ] Drone
  - [ ] Retrofit to existing vehicle
  - [ ] ______________
- [ ] Software:
  - [ ] Digital twinning
  - [ ] Simulation
  - [ ] Integration
  - [ ] ______________

- [ ] Other:

Ingredient technologies,

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E. Value Drivers

- [x] Nutrition (more food available)
- [ ] Environment (climate, organic, etc)
- [x] Quality (higher quality products for the customers)
- [ ] Economy (less costly products for the customer, higher revenue for the producer)
- [ ] Ergonomy & Safety (less manual work required, improved work-environment)
- [x] Technology (to be in the front line within technology development)
- [ ] Job creation (more jobs, keeping jobs in Europe)

- [ ] Other:

Waste reduction

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agROBOfood – Technology Mapping

Introduction:

This questionnaire is used to map robotic technologies that should be used more in the agri-food sector – from planning and production to processing and transportation – both existing technologies as well as potential technologies that can be transferred from other sectors. The intent is to create better solutions for the industry – with better interfacing, re-use & standardisation. Thank you for your input and assistance!

Please fill out separate copies of this document with only one technology reported per saved PDF-file.
Submit your contribution to the technology mapping by Apr 1 2020. Send by e-mail to rhk@dti.dk

High-level benefit to Agri-Food domain:	What is stopping the development?
Outline the value added by using this technology Will allow spot spraying and target-spraying (grasses/broad-leaved weeds)	What are the technical blockers and critical risks that prevent the development from happening today? -Neuronal Network training costs and time needed -Hardware (camera) dependent -High costs will reflect on final product prices -Could the final product be integrated with different hardware solutions?

Description:

Describe the technology and its possible application. What steps are needed to validate it in the agri-food domain? If possible, provide figures for estimated timescale and investments required.

Camera-based weed recognition would be used on weeding devices such as field robots and sprayers for spot application of chemical or mechanical removal of weeds.
Large investments needed for the Artificial Intelligence/Neuronal network part: both for coding as well as for training with images.

Current status of the technology:	Current TRL:
Please indicate in which sectors technology is used (if outside agri-food domain). Give references to existing installations, if applicable (company, location etc). Currently used in few AG robots and sprayers. Limited number of weeds recognized.	TRL1 = Basic principles observed TRL9 = Actual system proven 4 to 8 (highly depending on the Company) **Agri-Food TRL:**

Current providers and/or Developer/research groups:

Carbon Bee Agtech - Bilberry - WEED-IT - Bosch Deepfield robotics - Agrifac - EcoRobotix - SwarmFarm Robotics

Contact details	Date / Version No.
Can we contact you for more info? If so, provide name, organisation and e-mail. Riccardo Besana, Consultant, DTI Agrotech, rbe@teknologisk.dk	30 Apr 2020

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825395

Searchable Keywords & Tags for Classification

A. Sectors

- [x] Primary Production, Agriculture, Horticulture:
  - [x] Greenhouse
  - [x] Field crops (arable land)
  - [ ] Grove and woody crops
  - [ ] Aquaculture
  - [ ] Fungiculture
  - [ ] Algaculture
  - [ ] Livestock
- [ ] Food Processing:
  - [ ] Meats, Fish, etc
  - [ ] Fruits, Vegetables
  - [ ] Cereals
  - [ ] Fungus
  - [ ] Algae
  - [ ] New foods
- [ ] Logistics, Distribution:
  - [ ] Packaging
  - [ ] Transportation
  - [ ] Storage
- [ ] Customer, Market:
  - [ ] Information
  - [ ] Transparency
  - [ ] Time-to-market
  - [ ] Organic

- [ ] Other:

____

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Instruction:

Please select as many keywords and detailed tags as possible; it will make it easier for others to locate this suggestion when searching.

B. Processes

- [x] Crops, Plants:
  - [ ] Preparing, Seeding, Seedlings
  - [ ] Replanting
  - [ ] Watering
  - [ ] Fertilising
  - [ ] Pollinating
  - [x] Weeding, Spraying
  - [ ] Mowing
  - [ ] Pruning
  - [ ] Monitoring
  - [ ] Harvesting
  - [ ] Transporting
- [ ] Livestock:
  - [ ] Insemination
  - [ ] Birthing
  - [ ] Feeding
  - [ ] Cleaning
  - [ ] Milking
  - [ ] Shearing
  - [ ] Searching
  - [ ] Vaccinating
  - [ ] Transporting
- [ ] Primary Processing:
  - [ ] Drying
  - [ ] Threshing, Winnowing
  - [ ] Milling
  - [ ] Shelling
  - [ ] Butchering
  - [ ] Deboning
  - [ ] Cutting
  - [ ] Freezing
  - [ ] Smoking
  - [ ] Pressing, Extracting
  - [ ] Filtering
  - [ ] Canning
  - [ ] Homogenizing
  - [ ] Pasteurizing
  - [ ] Packaging
  - [ ] Transporting
- [ ] Secondary Processing:
  - [ ] Comminution
  - [ ] Fermenting
  - [ ] Baking
  - [ ] Cooking
  - [ ] Transporting
- [ ] Other:

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C. Products

- [ ] Livestock:
  - [ ] Cattle
  - [ ] Poultry
  - [ ] Pig
  - [ ] Goat
  - [ ] Sheep
  - [ ] Fish
- [x] Grains & Field Crops:
  - [ ] Barley
  - [ ] Wheat
  - [ ] Maize/Corn
  - [ ] ______________
- [ ] Fruits:
  - [ ] Grapes
  - [ ] Apples & Pears
  - [ ] Berries
  - [ ] ______________
- [x] Vegetables:
  - [ ] Salad
  - [ ] Tomatoes
  - [ ] ______________
- [ ] Plants:
  - [ ] Roses
  - [ ] Tulips
  - [ ] ______________
- [ ] Animal Products:
  - [ ] Milk
  - [ ] Meat
  - [ ] Eggs
  - [ ] ______________
- [ ] "Data":
  - [ ] Growth info
  - [ ] Health info
  - [ ] ______________

- [ ] Other:

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D. Technologies

- [x] Robot Technologies
  - [x] Vision
  - [ ] Control
  - [ ] Path planning
  - [ ] Navigation
  - [ ] Safety
  - [ ] Connectivity
  - [ ] Data analytics
  - [ ] Grippers/Grasping
  - [ ] ______________
- [x] Robot Type, Platform:
  - [x] Mobile robot
  - [ ] Manipulator
  - [x] Drone
  - [x] Retrofit to existing vehicle
  - [ ] ______________
- [ ] Software:
  - [ ] Digital twinning
  - [ ] Simulation
  - [ ] Integration
  - [ ] ______________

- [ ] Other:

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E. Value Drivers

- [ ] Nutrition
  (more food available)
- [x] Environment
  (climate, organic, etc)
- [x] Quality
  (higher quality products for the customers)
- [x] Economy
  (less costly products for the customer, higher revenue for the producer)
- [x] Ergonomy & Safety
  (less manual work required, improved work-environment)
- [x] Technology
  (to be in the front line within technology development)
- [x] Job creation
  (more jobs, keeping jobs in Europe)

- [ ] Other:

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agROBOfood – Technology Mapping

Introduction:

This questionnaire is used to map robotic technologies that should be used more in the agri-food sector – from planning and production to processing and transportation – both existing technologies as well as potential technologies that can be transferred from other sectors. The intent is to create better solutions for the industry – with better interfacing, re-use & standardisation. Thank you for your input and assistance!

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High-level benefit to Agri-Food domain:
Outline the value added by using this technology

Coordination of robots in the field should increase the working capacity and automation of the production operations.

What is stopping the development?
What are the technical blockers and critical risks that prevent the development from happening today?

Development of:
- telecommunication protocols
- fleet management architecture
- route planning software
-Lack of safety standards

Description:
Describe the technology and its possible application. What steps are needed to validate it in the agri-food domain? If possible, provide figures for estimated timescale and investments required.

In mobile robot fleet, robot will cooperate in teams to solve different tasks and will be able to take over other units job, if something goes wrong (e.g. seed tank empty, failures...).
The investment of time and money will be large because this system requires proven technologies in communication robustness and safety, AI, autonomous vehicles safety standards.
I think it might take 5 years before any product will be market ready.

Current status of the technology:
Please indicate in which sectors technology is used (if outside agri-food domain). Give references to existing installations, if applicable (company, location etc).

It's a technology that is still being developed and will be applied to AG robots once ready.
There are concepts from Continental/Fendt of their vision of robot fleets, but there haven't been news about the technology development in the last year.

Current TRL:
TRL1 = Basic principles observed
TRL9 = Actual system proven

2-3

Agri-Food TRL:
2-3

Current providers and/or Developer/research groups:

Continental, Fendt (TRL 2-3)
Small Robot Company (TRL 4-5)

Contact details
Can we contact you for more info? If so, provide name, organisation and e-mail.

Riccardo Besana, DTI AgroTech, rbe@teknologisk.dk

Date / Version No.
30 April 2020

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825395

Searchable Keywords & Tags for Classification

A. Sectors

- ☑ Primary Production, Agriculture, Horticulture:
  - ☑ Greenhouse
  - ☑ Field crops (arable land)
  - ☐ Grove and woody crops
  - ☐ Aquaculture
  - ☐ Fungiculture
  - ☐ Algaculture
  - ☐ Livestock
- ☐ Food Processing:
  - ☐ Meats, Fish, etc
  - ☐ Fruits, Vegetables
  - ☐ Cereals
  - ☐ Fungus
  - ☐ Algae
  - ☐ New foods
- ☑ Logistics, Distribution:
  - ☐ Packaging
  - ☑ Transportation
  - ☑ Storage
- ☐ Customer, Market:
  - ☐ Information
  - ☐ Transparency
  - ☐ Time-to-market
  - ☐ Organic
- ☐ Other:

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Instruction:

Please select as many keywords and detailed tags as possible; it will make it easier for others to locate this suggestion when searching.

B. Processes

- ☑ Crops, Plants:
  - ☑ Preparing, Seeding, Seedlings
  - ☑ Replanting
  - ☐ Watering
  - ☑ Fertilising
  - ☐ Pollinating
  - ☑ Weeding, Spraying
  - ☑ Mowing
  - ☐ Pruning
  - ☑ Monitoring
  - ☑ Harvesting
  - ☑ Transporting
- ☐ Livestock:
  - ☐ Insemination
  - ☐ Birthing
  - ☐ Feeding
  - ☐ Cleaning
  - ☐ Milking
  - ☐ Shearing
  - ☐ Searching
  - ☐ Vaccinating
  - ☐ Transporting
- ☐ Primary Processing:
  - ☐ Drying
  - ☐ Threshing, Winnowing
  - ☐ Milling
  - ☐ Shelling
  - ☐ Butchering
  - ☐ Deboning
  - ☐ Cutting
  - ☐ Freezing
  - ☐ Smoking
  - ☐ Pressing, Extracting
  - ☐ Filtering
  - ☐ Canning
  - ☐ Homogenizing
  - ☐ Pasteurizing
  - ☐ Packaging
  - ☐ Transporting
- ☐ Secondary Processing:
  - ☐ Comminution
  - ☐ Fermenting
  - ☐ Baking
  - ☐ Cooking
  - ☐ Transporting
- ☐ Other:

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C. Products

- ☐ Livestock:
  - ☐ Cattle
  - ☐ Poultry
  - ☐ Pig
  - ☐ Goat
  - ☐ Sheep
  - ☐ Fish
- ☑ Grains & Field Crops:
  - ☐ Barley
  - ☐ Wheat
  - ☐ Maize/Corn
  - ☐ ______________
- ☑ Fruits:
  - ☐ Grapes
  - ☐ Apples & Pears
  - ☐ Berries
  - ☐ ______________
- ☑ Vegetables:
  - ☐ Salad
  - ☐ Tomatoes
  - ☐ ______________
- ☑ Plants:
  - ☐ Roses
  - ☐ Tulips
  - ☐ ______________
- ☐ Animal Products:
  - ☐ Milk
  - ☐ Meat
  - ☐ Eggs
  - ☐ ______________
- ☐ "Data":
  - ☐ Growth info
  - ☐ Health info
  - ☐ ______________
- ☐ Other:

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D. Technologies

- ☑ Robot Technologies
  - ☐ Vision
  - ☑ Control
  - ☑ Path planning
  - ☑ Navigation
  - ☑ Safety
  - ☑ Connectivity
  - ☑ Data analytics
  - ☐ Grippers/Grasping
  - ☐ ______________
- ☑ Robot Type, Platform:
  - ☑ Mobile robot
  - ☑ Manipulator
  - ☑ Drone
  - ☐ Retrofit to existing vehicle
  - ☐ ______________
- ☑ Software:
  - ☑ Digital twinning
  - ☑ Simulation
  - ☐ Integration
  - ☐ ______________
- ☐ Other:

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E. Value Drivers

- ☐ Nutrition (more food available)
- ☑ Environment (climate, organic, etc)
- ☐ Quality (higher quality products for the customers)
- ☐ Economy (less costly products for the customer, higher revenue for the producer)
- ☑ Ergonomy & Safety (less manual work required, improved work-environment)
- ☑ Technology (to be in the front line within technology development)
- ☑ Job creation (more jobs, keeping jobs in Europe)
- ☐ Other:

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agROBOfood – Technology Mapping

Introduction:

This questionnaire is used to map robotic technologies that should be used more in the agri-food sector – from planning and production to processing and transportation – both existing technologies as well as potential technologies that can be transferred from other sectors. The intent is to create better solutions for the industry – with better interfacing, re-use & standardisation. Thank you for your input and assistance!

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High-level benefit to Agri-Food domain:	What is stopping the development?
Outline the value added by using this technology	What are the technical blockers and critical risks that prevent the development from happening today?
Fully autonomous vehicles in the fields that can cope with errors and consequently need less maintenance.	Devlopment is ongoing, technology is getting ready for market.

Description:

Describe the technology and its possible application. What steps are needed to validate it in the agri-food domain? If possible, provide figures for estimated timescale and investments required.

Fraunhofer IPA develops error detection, identification and recovery algorithms for robots. These can be especially useful for agricultural robots. If an error occurs on an autonomous robot in the field, it might lead to the robot being stuck somewhere in the field. In a worst case scenario, the farmer than needs to pull the robot out of the field which can destroy parts of the crops. The technology is agnostic of the applicaiton and can thus be applied on any robot application.

Current status of the technology:	Current TRL:
Please indicate in which sectors technology is used (if outside agri-food domain). Give references to existing installations, if applicable (company, location etc).	TRL1 = Basic principles observed TRL9 = Actual system proven
Technologies are used in industrial applications and can easily be adapted to the agricultural sector.	6-7
	Agri-Food TRL:
	4

Current providers and/or Developer/research groups:

Fraunhofer IPA

Contact details	Date / Version No.
Can we contact you for more info? If so, provide name, organisation and e-mail.	30.03.2020
christoph.hellmann.santos@ipa.fraunhofer.de	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825395

Searchable Keywords & Tags for Classification

A. Sectors

- ☑ Primary Production, Agriculture, Horticulture:
  - ☐ Greenhouse
  - ☐ Field crops (arable land)
  - ☐ Grove and woody crops
  - ☐ Aquaculture
  - ☐ Fungiculture
  - ☐ Algaculture
  - ☐ Livestock
- ☑ Food Processing:
  - ☐ Meats, Fish, etc
  - ☐ Fruits, Vegetables
  - ☐ Cereals
  - ☐ Fungus
  - ☐ Algae
  - ☐ New foods
- ☑ Logistics, Distribution:
  - ☐ Packaging
  - ☐ Transportation
  - ☐ Storage
- ☐ Customer, Market:
  - ☐ Information
  - ☐ Transparency
  - ☐ Time-to-market
  - ☐ Organic
- ☐ Other:

____

____

Instruction:

Please select as many keywords and detailed tags as possible; it will make it easier for others to locate this suggestion when searching.

B. Processes

- ☑ Crops, Plants:
  - ☐ Preparing, Seeding, Seedlings
  - ☐ Replanting
  - ☐ Watering
  - ☐ Fertilising
  - ☐ Pollinating
  - ☐ Weeding, Spraying
  - ☐ Mowing
  - ☐ Pruning
  - ☐ Monitoring
  - ☐ Harvesting
  - ☐ Transporting
- ☑ Livestock:
  - ☐ Insemination
  - ☐ Birthing
  - ☐ Feeding
  - ☐ Cleaning
  - ☐ Milking
  - ☐ Shearing
  - ☐ Searching
  - ☐ Vaccinating
  - ☐ Transporting
- ☑ Primary Processing:
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  - ☐ Threshing, Winnowing
  - ☐ Milling
  - ☐ Shelling
  - ☐ Butchering
  - ☐ Deboning
  - ☐ Cutting
  - ☐ Freezing
  - ☐ Smoking
  - ☐ Pressing, Extracting
  - ☐ Filtering
  - ☐ Canning
  - ☐ Homogenizing
  - ☐ Pasteurizing
  - ☐ Packaging
  - ☐ Transporting
- ☑ Secondary Processing:
  - ☐ Comminution
  - ☐ Fermenting
  - ☐ Baking
  - ☐ Cooking
  - ☐ Transporting
- ☐ Other:

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C. Products

- ☑ Livestock:
  - ☐ Cattle
  - ☐ Poultry
  - ☐ Pig
  - ☐ Goat
  - ☐ Sheep
  - ☐ Fish
- ☑ Grains & Field Crops:
  - ☐ Barley
  - ☐ Wheat
  - ☐ Maize/Corn
  - ☐ ______________
- ☑ Fruits:
  - ☐ Grapes
  - ☐ Apples & Pears
  - ☐ Berries
  - ☐ ______________
- ☑ Vegetables:
  - ☐ Salad
  - ☐ Tomatoes
  - ☐ ______________
- ☑ Plants:
  - ☐ Roses
  - ☐ Tulips
  - ☐ ______________
- ☐ Animal Products:
  - ☐ Milk
  - ☐ Meat
  - ☐ Eggs
  - ☐ ______________
- ☐ "Data":
  - ☐ Growth info
  - ☐ Health info
  - ☐ ______________
- ☐ Other:

____

____

D. Technologies

- ☑ Robot Technologies
  - ☐ Vision
  - ☐ Control
  - ☑ Path planning
  - ☑ Navigation
  - ☐ Safety
  - ☐ Connectivity
  - ☐ Data analytics
  - ☐ Grippers/Grasping
  - ☐ ______________
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  - ☐ Drone
  - ☐ Retrofit to existing vehicle
  - ☐ ______________
- ☑ Software:
  - ☐ Digital twinning
  - ☐ Simulation
  - ☐ Integration
  - ☐ ______________
- ☐ Other:

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E. Value Drivers

- ☐ Nutrition
  (more food available)
- ☐ Environment
  (climate, organic, etc)
- ☐ Quality
  (higher quality products for the customers)
- ☐ Economy
  (less costly products for the customer, higher revenue for the producer)
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  (less manual work required, improved work-environment)
- ☑ Technology
  (to be in the front line within technology development)
- ☐ Job creation
  (more jobs, keeping jobs in Europe)
- ☐ Other:

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agROBOfood – Technology Mapping

Introduction:

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High-level benefit to Agri-Food domain:
Outline the value added by using this technology

Fully autonomous vehicles in the fields

What is stopping the development?
What are the technical blockers and critical risks that prevent the development from happening today?

Devlopment is ongoing, technology is getting ready for market.

Description:
Describe the technology and its possible application. What steps are needed to validate it in the agri-food domain? If possible, provide figures for estimated timescale and investments required.

Enable efficient path planning for agricultural robots. Robots need to navigate in fields and have the smallest impact possible on the field. Fraunhofer IPA has adapted planning technologies from industrial applications, such as robots cleaning, that can be adopted for agricultural robot applicaitons.

Current status of the technology:
Please indicate in which sectors technology is used (if outside agri-food domain). Give references to existing installations, if applicable (company, location etc).

Technologies are used in industrial applications and need to be adapted to the agricultural sector.

Current TRL:
TRL1 = Basic principles observed
TRL9 = Actual system proven

8-9

Agri-Food TRL:

4-5

Current providers and/or Developer/research groups:

Fraunhofer IPA

Contact details
Can we contact you for more info? If so, provide name, organisation and e-mail.

christoph.hellmann.santos@ipa.fraunhofer.de

Date / Version No.
30.03.2020

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  - ☐ Livestock
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  - ☐ Meats, Fish, etc
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  - ☐ Fungus
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  - ☐ Packaging
  - ☐ Transportation
  - ☐ Storage
- ☐ Customer, Market:
  - ☐ Information
  - ☐ Transparency
  - ☐ Time-to-market
  - ☐ Organic
- ☐ Other:

____

____

Instruction:

Please select as many keywords and detailed tags as possible; it will make it easier for others to locate this suggestion when searching.

B. Processes

- ☑ Crops, Plants:
  - ☐ Preparing, Seeding, Seedlings
  - ☐ Replanting
  - ☐ Watering
  - ☐ Fertilising
  - ☐ Pollinating
  - ☐ Weeding, Spraying
  - ☐ Mowing
  - ☐ Pruning
  - ☐ Monitoring
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  - ☐ Transporting
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  - ☐ Milking
  - ☐ Shearing
  - ☐ Searching
  - ☐ Vaccinating
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  - ☐ Threshing, Winnowing
  - ☐ Milling
  - ☐ Shelling
  - ☐ Butchering
  - ☐ Deboning
  - ☐ Cutting
  - ☐ Freezing
  - ☐ Smoking
  - ☐ Pressing, Extracting
  - ☐ Filtering
  - ☐ Canning
  - ☐ Homogenizing
  - ☐ Pasteurizing
  - ☐ Packaging
  - ☐ Transporting
- ☑ Secondary Processing:
  - ☐ Comminution
  - ☐ Fermenting
  - ☐ Baking
  - ☐ Cooking
  - ☐ Transporting
- ☐ Other:

____

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C. Products

- ☑ Livestock:
  - ☐ Cattle
  - ☐ Poultry
  - ☐ Pig
  - ☐ Goat
  - ☐ Sheep
  - ☐ Fish
- ☑ Grains & Field Crops:
  - ☐ Barley
  - ☐ Wheat
  - ☐ Maize/Corn
  - ☐ ____________
- ☑ Fruits:
  - ☐ Grapes
  - ☐ Apples & Pears
  - ☐ Berries
  - ☐ ____________
- ☑ Vegetables:
  - ☐ Salad
  - ☐ Tomatoes
  - ☐ ____________
- ☑ Plants:
  - ☐ Roses
  - ☐ Tulips
  - ☐ ____________
- ☑ Animal Products:
  - ☐ Milk
  - ☐ Meat
  - ☐ Eggs
  - ☐ ____________
- ☑ "Data":
  - ☐ Growth info
  - ☐ Health info
  - ☐ ____________
- ☐ Other:

____

____

D. Technologies

- ☑ Robot Technologies
  - ☐ Vision
  - ☐ Control
  - ☐ Path planning
  - ☐ Navigation
  - ☐ Safety
  - ☐ Connectivity
  - ☐ Data analytics
  - ☐ Grippers/Grasping
  - ☐ ____________
- ☐ Robot Type, Platform:
  - ☐ Mobile robot
  - ☐ Manipulator
  - ☐ Drone
  - ☐ Retrofit to existing vehicle
  - ☐ ____________
- ☑ Software:
  - ☐ Digital twinning
  - ☐ Simulation
  - ☐ Integration
  - ☐ ____________
- ☐ Other:

____

____

E. Value Drivers

- ☐ Nutrition
  (more food available)
- ☐ Environment
  (climate, organic, etc)
- ☐ Quality
  (higher quality products for the customers)
- ☐ Economy
  (less costly products for the customer, higher revenue for the producer)
- ☐ Ergonomy & Safety
  (less manual work required, improved work-environment)
- ☑ Technology
  (to be in the front line within technology development)
- ☑ Job creation
  (more jobs, keeping jobs in Europe)
- ☐ Other:

____

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agROBOfood – Technology Mapping

Introduction:

This questionnaire is used to map robotic technologies that should be used more in the agri-food sector – from planning and production to processing and transportation – both existing technologies as well as potential technologies that can be transferred from other sectors. The intent is to create better solutions for the industry – with better interfacing, re-use & standardisation. Thank you for your input and assistance!

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Submit your contribution to the technology mapping by Apr 1 2020. Send by e-mail to rhk@dti.dk

High-level benefit to Agri-Food domain:
Outline the value added by using this technology

Fast creation of robot prototypes and agricultural robot products

What is stopping the development?
What are the technical blockers and critical risks that prevent the development from happening today?

Devlopment is ongoing. Agricultural activities could profit of more support from industry

Description:
Describe the technology and its possible application. What steps are needed to validate it in the agri-food domain? If possible, provide figures for estimated timescale and investments required.

ROS is a software framework and a middleware, that enables controlling robots. It has a huge ecosystem of existing software components and libraries. It is open source and can be used by anyone.

Current status of the technology:
Please indicate in which sectors technology is used (if outside agri-food domain). Give references to existing installations, if applicable (company, location etc).

ROS is open source and available to anyone. It is being used in some agricultural robots for example by Framwise and Naio

Current TRL:
TRL1 = Basic principles observed
TRL9 = Actual system proven

8-9

Agri-Food TRL:

4-9

Current providers and/or Developer/research groups:

Fraunhofer IPA, ROS Industrial Consortium
Tu Delft

Contact details
Can we contact you for more info? If so, provide name, organisation and e-mail.

christoph.hellmann.santos@ipa.fraunhofer.de

Date / Version No.
30.03.2020

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825395

Searchable Keywords & Tags for Classification

A. Sectors

- ☑ Primary Production, Agriculture, Horticulture:
  - ☐ Greenhouse
  - ☐ Field crops (arable land)
  - ☐ Grove and woody crops
  - ☐ Aquaculture
  - ☐ Fungiculture
  - ☐ Algaculture
  - ☐ Livestock
- ☑ Food Processing:
  - ☐ Meats, Fish, etc
  - ☐ Fruits, Vegetables
  - ☐ Cereals
  - ☐ Fungus
  - ☐ Algae
  - ☐ New foods
- ☑ Logistics, Distribution:
  - ☐ Packaging
  - ☐ Transportation
  - ☐ Storage
- ☐ Customer, Market:
  - ☐ Information
  - ☐ Transparency
  - ☐ Time-to-market
  - ☐ Organic
- ☐ Other:

____

____

Instruction:

Please select as many keywords and detailed tags as possible; it will make it easier for others to locate this suggestion when searching.

B. Processes

- ☑ Crops, Plants:
  - ☐ Preparing, Seeding, Seedlings
  - ☐ Replanting
  - ☐ Watering
  - ☐ Fertilising
  - ☐ Pollinating
  - ☐ Weeding, Spraying
  - ☐ Mowing
  - ☐ Pruning
  - ☐ Monitoring
  - ☐ Harvesting
  - ☐ Transporting
- ☑ Livestock:
  - ☐ Insemination
  - ☐ Birthing
  - ☐ Feeding
  - ☐ Cleaning
  - ☐ Milking
  - ☐ Shearing
  - ☐ Searching
  - ☐ Vaccinating
  - ☐ Transporting
- ☑ Primary Processing:
  - ☐ Drying
  - ☐ Threshing, Winnowing
  - ☐ Milling
  - ☐ Shelling
  - ☐ Butchering
  - ☐ Deboning
  - ☐ Cutting
  - ☐ Freezing
  - ☐ Smoking
  - ☐ Pressing, Extracting
  - ☐ Filtering
  - ☐ Canning
  - ☐ Homogenizing
  - ☐ Pasteurizing
  - ☐ Packaging
  - ☐ Transporting
- ☑ Secondary Processing:
  - ☐ Comminution
  - ☐ Fermenting
  - ☐ Baking
  - ☐ Cooking
  - ☐ Transporting
- ☐ Other:

____

____

C. Products

- ☑ Livestock:
  - ☐ Cattle
  - ☐ Poultry
  - ☐ Pig
  - ☐ Goat
  - ☐ Sheep
  - ☐ Fish
- ☑ Grains & Field Crops:
  - ☐ Barley
  - ☐ Wheat
  - ☐ Maize/Corn
  - ☐ ______________
- ☑ Fruits:
  - ☐ Grapes
  - ☐ Apples & Pears
  - ☐ Berries
  - ☐ ______________
- ☑ Vegetables:
  - ☐ Salad
  - ☐ Tomatoes
  - ☐ ______________
- ☑ Plants:
  - ☐ Roses
  - ☐ Tulips
  - ☐ ______________
- ☑ Animal Products:
  - ☐ Milk
  - ☐ Meat
  - ☐ Eggs
  - ☐ ______________
- ☑ "Data":
  - ☐ Growth info
  - ☐ Health info
  - ☐ ______________
- ☐ Other:

____

____

D. Technologies

- ☑ Robot Technologies
  - ☐ Vision
  - ☐ Control
  - ☐ Path planning
  - ☐ Navigation
  - ☐ Safety
  - ☐ Connectivity
  - ☐ Data analytics
  - ☐ Grippers/Grasping
  - ☐ ______________
- ☐ Robot Type, Platform:
  - ☐ Mobile robot
  - ☐ Manipulator
  - ☐ Drone
  - ☐ Retrofit to existing vehicle
  - ☐ ______________
- ☑ Software:
  - ☐ Digital twinning
  - ☐ Simulation
  - ☐ Integration
  - ☐ ______________
- ☐ Other:

____

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E. Value Drivers

- ☐ Nutrition
  (more food available)
- ☐ Environment
  (climate, organic, etc)
- ☐ Quality
  (higher quality products for the customers)
- ☐ Economy
  (less costly products for the customer, higher revenue for the producer)
- ☐ Ergonomy & Safety
  (less manual work required, improved work-environment)
- ☑ Technology
  (to be in the front line within technology development)
- ☑ Job creation
  (more jobs, keeping jobs in Europe)
- ☐ Other:

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agROBOfood – Technology Mapping

Introduction:

This questionnaire is used to map robotic technologies that should be used more in the agri-food sector – from planning and production to processing and transportation – both existing technologies as well as potential technologies that can be transferred from other sectors. The intent is to create better solutions for the industry – with better interfacing, re-use & standardisation. Thank you for your input and assistance!

Please fill out separate copies of this document with only one technology reported per saved PDF-file.
Submit your contribution to the technology mapping by March 15, 2020. Send by e-mail to vanja.bisevac@cema-agri.org

High-level benefit to Agri-Food domain:
Outline the value added by using this technology

Speed up market introduction for autonomous systems.
Joint effort may reduce cost

What is stopping the development?
What are the technical blockers and critical risks that prevent the development from happening today?

Description:
Describe the technology and its possible application. What steps are needed to validate it in the agri-food domain? If possible, provide figures for estimated timescale and investments required.

In many cases, robots are not (only) a technological challenge, but the regulatory framework to introduce them on the market. It appears plausible to investigate on certifyability of components and entire systems.

Current status of the technology:
Please indicate in which sectors technology is used (if outside agri-food domain). Give references to existing installations, if applicable (company, location etc).

Sensors with certification for autonomous applications are significant higher

Current TRL:
TRL1 = Basic principles observed
TRL9 = Actual system proven

Agri-Food TRL:

Current providers and/or Developer/research groups:

Contact details
Can we contact you for more info? If so, provide name, organisation and e-mail.

Thilo Steckel, CLAAS E-Systems
thilo.steckel@claas.com

Date / Version No.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825395

Searchable Keywords & Tags for Classification

A. Sectors

- [x] Primary Production, Agriculture, Horticulture:
  - [ ] Greenhouse
  - [ ] Field crops (arable land)
  - [ ] Grove and woody crops
  - [ ] Aquaculture
  - [ ] Fungiculture
  - [ ] Algaculture
  - [ ] Livestock
- [ ] Food Processing:
  - [ ] Meats, Fish, etc
  - [ ] Fruits, Vegetables
  - [ ] Cereals
  - [ ] Fungus
  - [ ] Algae
  - [ ] New foods
- [ ] Logistics, Distribution:
  - [ ] Packaging
  - [ ] Transportation
  - [ ] Storage
- [ ] Customer, Market:
  - [ ] Information
  - [ ] Transparency
  - [x] Time-to-market
  - [ ] Organic

- [ ] Other:

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Instruction:

Please select as many keywords and detailed tags as possible; it will make it easier for others to locate this suggestion when searching.

B. Processes

- [x] Crops, Plants:
  - [ ] Preparing, Seeding, Seedlings
  - [ ] Replanting
  - [ ] Watering
  - [ ] Fertilising
  - [ ] Pollinating
  - [ ] Weeding, Spraying
  - [ ] Mowing
  - [ ] Pruning
  - [ ] Monitoring
  - [ ] Harvesting
  - [ ] Transporting
- [x] Livestock:
  - [ ] Insemination
  - [ ] Birthing
  - [ ] Feeding
  - [ ] Cleaning
  - [ ] Milking
  - [ ] Shearing
  - [ ] Searching
  - [ ] Vaccinating
  - [ ] Transporting
- [x] Primary Processing:
  - [ ] Drying
  - [ ] Threshing, Winnowing
  - [ ] Milling
  - [ ] Shelling
  - [ ] Butchering
  - [ ] Deboning
  - [ ] Cutting
  - [ ] Freezing
  - [ ] Smoking
  - [ ] Pressing, Extracting
  - [ ] Filtering
  - [ ] Canning
  - [ ] Homogenizing
  - [ ] Pasteurizing
  - [ ] Packaging
  - [ ] Transporting
- [ ] Secondary Processing:
  - [ ] Comminution
  - [ ] Fermenting
  - [ ] Baking
  - [ ] Cooking
  - [ ] Transporting
- [ ] Other:

____

____

C. Products

- [ ] Livestock:
  - [ ] Cattle
  - [ ] Poultry
  - [ ] Pig
  - [ ] Goat
  - [ ] Sheep
  - [ ] Fish
- [ ] Grains & Field Crops:
  - [ ] Barley
  - [ ] Wheat
  - [ ] Maize/Corn
  - [ ] ____________
- [ ] Fruits:
  - [ ] Grapes
  - [ ] Apples & Pears
  - [ ] Berries
  - [ ] ____________
- [ ] Vegetables:
  - [ ] Salad
  - [ ] Tomatoes
  - [ ] ____________
- [ ] Plants:
  - [ ] Roses
  - [ ] Tulips
  - [ ] ____________
- [ ] Animal Products:
  - [ ] Milk
  - [ ] Meat
  - [ ] Eggs
  - [ ] ____________
- [ ] "Data":
  - [ ] Growth info
  - [ ] Health info
  - [ ] ____________

- [ ] Other:

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D. Technologies

- [ ] Robot Technologies
  - [ ] Vision
  - [ ] Control
  - [ ] Path planning
  - [ ] Navigation
  - [ ] Safety
  - [ ] Connectivity
  - [ ] Data analytics
  - [ ] Grippers/Grasping
  - [ ] ____________
- [ ] Robot Type, Platform:
  - [x] Mobile robot
  - [ ] Manipulator
  - [ ] Drone
  - [ ] Retrofit to existing vehicle
  - [ ] ____________
- [ ] Software:
  - [ ] Digital twinning
  - [ ] Simulation
  - [x] Integration
  - [ ] ____________

- [ ] Other:

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E. Value Drivers

- [ ] Nutrition
  (more food available)
- [ ] Environment
  (climate, organic, etc)
- [ ] Quality
  (higher quality products for the customers)
- [x] Economy
  (less costly products for the customer, higher revenue for the producer)
- [ ] Ergonomy & Safety
  (less manual work required, improved work-environment)
- [x] Technology
  (to be in the front line within technology development)
- [ ] Job creation
  (more jobs, keeping jobs in Europe)

- [ ] Other:

____

____

agROBOfood – Technology Mapping

Introduction:

This questionnaire is used to map robotic technologies that should be used more in the agri-food sector – from planning and production to processing and transportation – both existing technologies as well as potential technologies that can be transferred from other sectors. The intent is to create better solutions for the industry – with better interfacing, re-use & standardisation. Thank you for your input and assistance!

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High-level benefit to Agri-Food domain:

Outline the value added by using this technology

Increase productivity
Reduce the arduousness
Prevent lack of manpower

What is stopping the development?

What are the technical blockers and critical risks that prevent the development from happening today?

Price of the tecnology

Description:

Describe the technology and its possible application. What steps are needed to validate it in the agri-food domain? If possible, provide figures for estimated timescale and investments required.

Automatic transport trolley without ground infrastructure. To transport any product from any place to another in the company.
Step needed :
- to be able to compute its localization in any place
- to be able to move in safe conditions
- to be able to comunicate with WMS

Current status of the technology:

Please indicate in which sectors technology is used (if outside agri-food domain). Give references to existing installations, if applicable (company, location etc).

This technology is mature and distributed by some providers but stay too expensive to be extended to Agri-food SME

Current TRL:

TRL1 = Basic principles observed
TRL9 = Actual system proven

9

Agri-Food TRL:

9

Current providers and/or Developer/research groups:

Balyo (https://www.balyo.fr/)
BA Systemes (https://www.basystemes.com/fr/)

Contact details

Can we contact you for more info? If so, provide name, organisation and e-mail.

Date / Version No.

03/31/2020

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825395

Searchable Keywords & Tags for Classification

A. Sectors

- ☐ Primary Production, Agriculture, Horticulture:
  - ☐ Greenhouse
  - ☐ Field crops (arable land)
  - ☐ Grove and woody crops
  - ☐ Aquaculture
  - ☐ Fungiculture
  - ☐ Algaculture
  - ☐ Livestock
- ☑ Food Processing:
  - ☑ Meats, Fish, etc
  - ☑ Fruits, Vegetables
  - ☑ Cereals
  - ☐ Fungus
  - ☐ Algae
  - ☐ New foods
- ☑ Logistics, Distribution:
  - ☑ Packaging
  - ☑ Transportation
  - ☑ Storage
- ☐ Customer, Market:
  - ☐ Information
  - ☐ Transparency
  - ☐ Time-to-market
  - ☐ Organic
- ☐ Other:

Instruction:

Please select as many keywords and detailed tags as possible; it will make it easier for others to locate this suggestion when searching.

B. Processes

- ☐ Crops, Plants:
  - ☐ Preparing, Seeding, Seedlings
  - ☐ Replanting
  - ☐ Watering
  - ☐ Fertilising
  - ☐ Pollinating
  - ☐ Weeding, Spraying
  - ☐ Mowing
  - ☐ Pruning
  - ☐ Monitoring
  - ☐ Harvesting
  - ☐ Transporting
- ☐ Livestock:
  - ☐ Insemination
  - ☐ Birthing
  - ☐ Feeding
  - ☐ Cleaning
  - ☐ Milking
  - ☐ Shearing
  - ☐ Searching
  - ☐ Vaccinating
  - ☐ Transporting
- ☐ Primary Processing:
  - ☐ Drying
  - ☐ Threshing, Winnowing
  - ☐ Milling
  - ☐ Shelling
  - ☐ Butchering
  - ☐ Deboning
  - ☐ Cutting
  - ☐ Freezing
  - ☐ Smoking
  - ☐ Pressing, Extracting
  - ☐ Filtering
  - ☐ Canning
  - ☐ Homogenizing
  - ☐ Pasteurizing
  - ☐ Packaging
  - ☐ Transporting
- ☐ Secondary Processing:
  - ☐ Comminution
  - ☐ Fermenting
  - ☐ Baking
  - ☐ Cooking
  - ☐ Transporting
- ☐ Other:

C. Products

- ☐ Livestock:
  - ☐ Cattle
  - ☐ Poultry
  - ☐ Pig
  - ☐ Goat
  - ☐ Sheep
  - ☐ Fish
- ☐ Grains & Field Crops:
  - ☐ Barley
  - ☐ Wheat
  - ☐ Maize/Corn
  - ☐ ____________
- ☐ Fruits:
  - ☐ Grapes
  - ☐ Apples & Pears
  - ☐ Berries
  - ☐ ____________
- ☐ Vegetables:
  - ☐ Salad
  - ☐ Tomatoes
  - ☐ ____________
- ☐ Plants:
  - ☐ Roses
  - ☐ Tulips
  - ☐ ____________
- ☐ Animal Products:
  - ☐ Milk
  - ☐ Meat
  - ☐ Eggs
  - ☐ ____________
- ☐ "Data":
  - ☐ Growth info
  - ☐ Health info
  - ☐ ____________
- ☐ Other:

D. Technologies

- ☑ Robot Technologies
  - ☑ Vision
  - ☑ Control
  - ☑ Path planning
  - ☑ Navigation
  - ☑ Safety
  - ☑ Connectivity
  - ☐ Data analytics
  - ☐ Grippers/Grasping
  - ☐ ____________
- ☐ Robot Type, Platform:
  - ☑ Mobile robot
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  - ☐ Drone
  - ☐ Retrofit to existing vehicle
  - ☐ ____________
- ☐ Software:
  - ☐ Digital twinning
  - ☐ Simulation
  - ☐ Integration
  - ☐ ____________
- ☐ Other:

E. Value Drivers

- ☐ Nutrition (more food available)
- ☐ Environment (climate, organic, etc)
- ☐ Quality (higher quality products for the customers)
- ☐ Economy (less costly products for the customer, higher revenue for the producer)
- ☐ Ergonomy & Safety (less manual work required, improved work-environment)
- ☐ Technology (to be in the front line within technology development)
- ☐ Job creation (more jobs, keeping jobs in Europe)
- ☐ Other:

agROBOfood – Technology Mapping

Introduction:

This questionnaire is used to map robotic technologies that should be used more in the agri-food sector – from planning and production to processing and transportation – both existing technologies as well as potential technologies that can be transferred from other sectors. The intent is to create better solutions for the industry – with better interfacing, re-use & standardisation. Thank you for your input and assistance!

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Submit your contribution to the technology mapping by Apr 1 2020. Send by e-mail to rhk@dti.dk

High-level benefit to Agri-Food domain:
Outline the value added by using this technology

Robust off-the-shelf manipulator will improve the use of this kind of tools in the field.

What is stopping the development?
What are the technical blockers and critical risks that prevent the development from happening today?

Precise manipulation in the fields is in prototype status.

Description:
Describe the technology and its possible application. What steps are needed to validate it in the agri-food domain? If possible, provide figures for estimated timescale and investments required.

Precise and robust manipulators. At industrial level, there are a lot of options for precise manipulators (robotic arms). However there is no specially-designed manipulators for agriculture, able to work outside.

Current status of the technology:
Please indicate in which sectors technology is used (if outside agri-food domain). Give references to existing installations, if applicable (company, location etc).

For industrial scenarios, this technology is very robust and mature.

Current TRL:
TRL1 = Basic principles observed
TRL9 = Actual system proven

9

Agri-Food TRL:
4

Current providers and/or Developer/research groups:
Kuka, Universal Robots, ABB

Contact details
Can we contact you for more info? If so, provide name, organisation and e-mail.

Date / Version No.
01/04/20

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825395

Searchable Keywords & Tags for Classification

A. Sectors

☑ Primary Production, Agriculture, Horticulture:
- ☑ Greenhouse
- ☑ Field crops (arable land)
- ☑ Grove and woody crops
- ☐ Aquaculture
- ☐ Fungiculture
- ☐ Algaculture
- ☐ Livestock

☐ Food Processing:
- ☐ Meats, Fish, etc
- ☐ Fruits, Vegetables
- ☐ Cereals
- ☐ Fungus
- ☐ Algae
- ☐ New foods

☐ Logistics, Distribution:
- ☐ Packaging
- ☐ Transportation
- ☐ Storage

☐ Customer, Market:
- ☐ Information
- ☐ Transparency
- ☐ Time-to-market
- ☐ Organic

☐ Other:

____

____

Instruction:

Please select as many keywords and detailed tags as possible; it will make it easier for others to locate this suggestion when searching.

B. Processes

☑ Crops, Plants:
- ☑ Preparing, Seeding, Seedlings
- ☐ Replanting
- ☐ Watering
- ☐ Fertilising
- ☐ Pollinating
- ☑ Weeding, Spraying
- ☐ Mowing
- ☑ Pruning
- ☐ Monitoring
- ☑ Harvesting
- ☐ Transporting

☐ Livestock:
- ☐ Insemination
- ☐ Birthing
- ☐ Feeding
- ☐ Cleaning
- ☐ Milking
- ☐ Shearing
- ☐ Searching
- ☐ Vaccinating
- ☐ Transporting

☐ Primary Processing:
- ☐ Drying
- ☐ Threshing, Winnowing
- ☐ Milling
- ☐ Shelling
- ☐ Butchering
- ☐ Deboning
- ☐ Cutting
- ☐ Freezing
- ☐ Smoking
- ☐ Pressing, Extracting
- ☐ Filtering
- ☐ Canning
- ☐ Homogenizing
- ☐ Pasteurizing
- ☐ Packaging
- ☐ Transporting

☐ Secondary Processing:
- ☐ Comminution
- ☐ Fermenting
- ☐ Baking
- ☐ Cooking
- ☐ Transporting

☐ Other:

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C. Products

☐ Livestock:
- ☐ Cattle
- ☐ Poultry
- ☐ Pig
- ☐ Goat
- ☐ Sheep
- ☐ Fish

☐ Grains & Field Crops:
- ☐ Barley
- ☐ Wheat
- ☐ Maize/Corn
- ☐ ______________

☑ Fruits:
- ☑ Grapes
- ☑ Apples & Pears
- ☑ Berries
- ☐ ______________

☑ Vegetables:
- ☑ Salad
- ☑ Tomatoes
- ☐ ______________

☑ Plants:
- ☑ Roses
- ☑ Tulips
- ☐ ______________

☐ Animal Products:
- ☐ Milk
- ☐ Meat
- ☐ Eggs
- ☐ ______________

☐ "Data":
- ☐ Growth info
- ☐ Health info
- ☐ ______________

☐ Other:

____

____

D. Technologies

☑ Robot Technologies
- ☑ Vision
- ☑ Control
- ☑ Path planning
- ☑ Navigation
- ☑ Safety
- ☑ Connectivity
- ☐ Data analytics
- ☐ Grippers/Grasping
- ☐ ______________

☑ Robot Type, Platform:
- ☐ Mobile robot
- ☑ Manipulator
- ☐ Drone
- ☐ Retrofit to existing vehicle
- ☐ ______________

☑ Software:
- ☐ Digital twinning
- ☐ Simulation
- ☑ Integration
- ☐ ______________

☐ Other:

____

____

E. Value Drivers

☐ Nutrition
(more food available)

☐ Environment
(climate, organic, etc)

☐ Quality
(higher quality products for the customers)

☐ Economy
(less costly products for the customer, higher revenue for the producer)

☐ Ergonomy & Safety
(less manual work required, improved work-environment)

☑ Technology
(to be in the front line within technology development)

☐ Job creation
(more jobs, keeping jobs in Europe)

☐ Other:

____

____

agROBOfood – Technology Mapping

Introduction:

This questionnaire is used to map robotic technologies that should be used more in the agri-food sector – from planning and production to processing and transportation – both existing technologies as well as potential technologies that can be transferred from other sectors. The intent is to create better solutions for the industry – with better interfacing, re-use & standardisation. Thank you for your input and assistance!

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Submit your contribution to the technology mapping by Apr 1 2020. Send by e-mail to rhk@dti.dk

High-level benefit to Agri-Food domain:	What is stopping the development?
Outline the value added by using this technology Easy access of small producers to autonomous vehicles	What are the technical blockers and critical risks that prevent the development from happening today? The maturity of the technology itself.

Description:

Describe the technology and its possible application. What steps are needed to validate it in the agri-food domain? If possible, provide figures for estimated timescale and investments required.

Tractor retrofitting for autonomous navigation. A solution for small-medium farms is transform regular tractors to autonomous vehicles.

Current status of the technology:	Current TRL:
Please indicate in which sectors technology is used (if outside agri-food domain). Give references to existing installations, if applicable (company, location etc). There are some compaines doing the “hardware adaptation” but without providing the smartness required for autonomous navigation	TRL1 = Basic principles observed TRL9 = Actual system proven 7 **Agri-Food TRL:** 5

Current providers and/or Developer/research groups:
AGreenCulture, GoTrack

Contact details	Date / Version No.
Can we contact you for more info? If so, provide name, organisation and e-mail.	01/04/20

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825395

Searchable Keywords & Tags for Classification

A. Sectors

- ☑ Primary Production, Agriculture, Horticulture:
  - ☑ Greenhouse
  - ☑ Field crops (arable land)
  - ☐ Grove and woody crops
  - ☐ Aquaculture
  - ☐ Fungiculture
  - ☐ Algaculture
  - ☐ Livestock
- ☐ Food Processing:
  - ☐ Meats, Fish, etc
  - ☐ Fruits, Vegetables
  - ☐ Cereals
  - ☐ Fungus
  - ☐ Algae
  - ☐ New foods
- ☐ Logistics, Distribution:
  - ☐ Packaging
  - ☐ Transportation
  - ☐ Storage
- ☐ Customer, Market:
  - ☐ Information
  - ☐ Transparency
  - ☐ Time-to-market
  - ☐ Organic

- ☐ Other:

____

____

Instruction:

Please select as many keywords and detailed tags as possible; it will make it easier for others to locate this suggestion when searching.

B. Processes

- ☑ Crops, Plants:
  - ☐ Preparing, Seeding, Seedlings
  - ☐ Replanting
  - ☐ Watering
  - ☐ Fertilising
  - ☐ Pollinating
  - ☐ Weeding, Spraying
  - ☐ Mowing
  - ☐ Pruning
  - ☐ Monitoring
  - ☐ Harvesting
  - ☐ Transporting
- ☐ Livestock:
  - ☐ Insemination
  - ☐ Birthing
  - ☐ Feeding
  - ☐ Cleaning
  - ☐ Milking
  - ☐ Shearing
  - ☐ Searching
  - ☐ Vaccinating
  - ☐ Transporting
- ☐ Primary Processing:
  - ☐ Drying
  - ☐ Threshing, Winnowing
  - ☐ Milling
  - ☐ Shelling
  - ☐ Butchering
  - ☐ Deboning
  - ☐ Cutting
  - ☐ Freezing
  - ☐ Smoking
  - ☐ Pressing, Extracting
  - ☐ Filtering
  - ☐ Canning
  - ☐ Homogenizing
  - ☐ Pasteurizing
  - ☐ Packaging
  - ☐ Transporting
- ☐ Secondary Processing:
  - ☐ Comminution
  - ☐ Fermenting
  - ☐ Baking
  - ☐ Cooking
  - ☐ Transporting
- ☐ Other:

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C. Products

- ☐ Livestock:
  - ☐ Cattle
  - ☐ Poultry
  - ☐ Pig
  - ☐ Goat
  - ☐ Sheep
  - ☐ Fish
- ☑ Grains & Field Crops:
  - ☐ Barley
  - ☐ Wheat
  - ☐ Maize/Corn
  - ☐ ____________
- ☑ Fruits:
  - ☐ Grapes
  - ☐ Apples & Pears
  - ☐ Berries
  - ☐ ____________
- ☑ Vegetables:
  - ☐ Salad
  - ☐ Tomatoes
  - ☐ ____________
- ☑ Plants:
  - ☐ Roses
  - ☐ Tulips
  - ☐ ____________
- ☐ Animal Products:
  - ☐ Milk
  - ☐ Meat
  - ☐ Eggs
  - ☐ ____________
- ☐ "Data":
  - ☐ Growth info
  - ☐ Health info
  - ☐ ____________

- ☐ Other:

____

____

D. Technologies

- ☑ Robot Technologies
  - ☐ Vision
  - ☑ Control
  - ☑ Path planning
  - ☑ Navigation
  - ☑ Safety
  - ☐ Connectivity
  - ☐ Data analytics
  - ☐ Grippers/Grasping
  - ☐ ____________
- ☑ Robot Type, Platform:
  - ☑ Mobile robot
  - ☐ Manipulator
  - ☐ Drone
  - ☐ Retrofit to existing vehicle
  - ☐ ____________
- ☑ Software:
  - ☐ Digital twinning
  - ☐ Simulation
  - ☑ Integration
  - ☐ ____________

- ☐ Other:

____

____

E. Value Drivers

- ☐ Nutrition (more food available)
- ☐ Environment (climate, organic, etc)
- ☐ Quality (higher quality products for the customers)
- ☑ Economy (less costly products for the customer, higher revenue for the producer)
- ☑ Ergonomy & Safety (less manual work required, improved work-environment)
- ☑ Technology (to be in the front line within technology development)
- ☐ Job creation (more jobs, keeping jobs in Europe)

- ☐ Other:

____

____

agROBOfood – Technology Mapping

Introduction:

This questionnaire is used to map robotic technologies that should be used more in the agri-food sector – from planning and production to processing and transportation – both existing technologies as well as potential technologies that can be transferred from other sectors. The intent is to create better solutions for the industry – with better interfacing, re-use & standardisation. Thank you for your input and assistance!

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High-level benefit to Agri-Food domain: Outline the value added by using this technology	What is stopping the development? What are the technical blockers and critical risks that prevent the development from happening today?
Soil sampling and analysis of nutrients in the field. It can provide precision agriculture with the necessary on-time data for optimizing the production to be more efficient with less environmental impact.	It is a challenging task. A lot of power is needed for soil sampling, analysis module should cover all nutrients of interest. The whole system should be robust enough for in-field applications. Soil sampling and analysis is not needed throughout the whole year and there should be some additional functionality to make the system more profitable.

Description:
Describe the technology and its possible application. What steps are needed to validate it in the agri-food domain? If possible, provide figures for estimated timescale and investments required.

The technology enables the accurate application of fertilizer based on near-real-time and georeferenced data of soil nutrients. Nutrients are both spatially and temporally variable. Currently, farmers collect soil samples manually, mix them and send the mixed sample to the lab and receive the results of their analysis in ca.15 days.
The sampling robot will be able to deliver nutrient (N, P, K) content results within 15-20 minutes per sample while still in the field. In this way, farmers will have on-time information about the distribution of nutrients in the field and to optimize their agricultural production. In this way, both economic and environmental benefits will be obtained.
About 30% of the costs of agriculture production in farming goes to fertilization. With the system that can offer reliable information about soil nutrients, these costs could be significantly reduced. Also, there is the environmental influence which is related to the excess usage of fertilizer that leads to pollution. Evaporation of fertilizer creates greenhouse gasses while leaching of excessive fertilizer leads to pollution of ground and surface waters.
Investment required for developing such the system is of the order of several 100k€, for the period of around 3 years at least.

Current status of the technology: Please indicate in which sectors technology is used (if outside agri-food domain). Give references to existing installations, if applicable (company, location etc).	Current TRL: TRL1 = Basic principles observed TRL9 = Actual system proven
Some companies are offering solutions that are not complete. The offered systems measure only part of the parameters such as organic matter, pH and EC.	9
	Agri-Food TRL: 5

Current providers and/or Developer/research groups:

Company Veris has system that measures EC, soil organic matter and pH.

Contact details: Can we contact you for more info? If so, provide name, organisation and e-mail.	Date / Version No. 01/04/20

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825395

Searchable Keywords & Tags for Classification

A. Sectors

- ☐ Primary Production, Agriculture, Horticulture:
  - ☑ Greenhouse
  - ☑ Field crops (arable land)
  - ☐ Grove and woody crops
  - ☐ Aquaculture
  - ☐ Fungiculture
  - ☐ Algaculture
  - ☐ Livestock
- ☐ Food Processing:
  - ☐ Meats, Fish, etc
  - ☐ Fruits, Vegetables
  - ☐ Cereals
  - ☐ Fungus
  - ☐ Algae
  - ☐ New foods
- ☐ Logistics, Distribution:
  - ☐ Packaging
  - ☐ Transportation
  - ☐ Storage
- ☐ Customer, Market:
  - ☐ Information
  - ☐ Transparency
  - ☐ Time-to-market
  - ☐ Organic
- ☐ Other:

Instruction:

Please select as many keywords and detailed tags as possible; it will make it easier for others to locate this suggestion when searching.

B. Processes

- ☑ Crops, Plants:
  - ☑ Preparing, Seeding, Seedlings
  - ☐ Replanting
  - ☐ Watering
  - ☑ Fertilising
  - ☐ Pollinating
  - ☐ Weeding, Spraying
  - ☐ Mowing
  - ☐ Pruning
  - ☑ Monitoring
  - ☐ Harvesting
  - ☐ Transporting
- ☐ Livestock:
  - ☐ Insemination
  - ☐ Birthing
  - ☐ Feeding
  - ☐ Cleaning
  - ☐ Milking
  - ☐ Shearing
  - ☐ Searching
  - ☐ Vaccinating
  - ☐ Transporting
- ☐ Primary Processing:
  - ☐ Drying
  - ☐ Threshing, Winnowing
  - ☐ Milling
  - ☐ Shelling
  - ☐ Butchering
  - ☐ Deboning
  - ☐ Cutting
  - ☐ Freezing
  - ☐ Smoking
  - ☐ Pressing, Extracting
  - ☐ Filtering
  - ☐ Canning
  - ☐ Homogenizing
  - ☐ Pasteurizing
  - ☐ Packaging
  - ☐ Transporting
- ☐ Secondary Processing:
  - ☐ Comminution
  - ☐ Fermenting
  - ☐ Baking
  - ☐ Cooking
  - ☐ Transporting
- ☐ Other:

C. Products

- ☐ Livestock:
  - ☐ Cattle
  - ☐ Poultry
  - ☐ Pig
  - ☐ Goat
  - ☐ Sheep
  - ☐ Fish
- ☑ Grains & Field Crops:
  - ☐ Barley
  - ☐ Wheat
  - ☐ Maize/Corn
  - ☐ ______________
- ☑ Fruits:
  - ☐ Grapes
  - ☐ Apples & Pears
  - ☐ Berries
  - ☐ ______________
- ☑ Vegetables:
  - ☐ Salad
  - ☐ Tomatoes
  - ☐ ______________
- ☑ Plants:
  - ☐ Roses
  - ☐ Tulips
  - ☐ ______________
- ☐ Animal Products:
  - ☐ Milk
  - ☐ Meat
  - ☐ Eggs
  - ☐ ______________
- ☑ "Data":
  - ☐ Growth info
  - ☐ Health info
  - ☐ ______________
- ☐ Other:

D. Technologies

- ☑ Robot Technologies
  - ☐ Vision
  - ☑ Control
  - ☑ Path planning
  - ☑ Navigation
  - ☐ Safety
  - ☐ Connectivity
  - ☑ Data analytics
  - ☐ Grippers/Grasping
  - ☐ ______________
- ☑ Robot Type, Platform:
  - ☑ Mobile robot
  - ☑ Manipulator
  - ☐ Drone
  - ☐ Retrofit to existing vehicle
  - ☐ ______________
- ☐ Software:
  - ☐ Digital twinning
  - ☐ Simulation
  - ☑ Integration
  - ☐ ______________
- ☐ Other:

E. Value Drivers

- ☑ Nutrition (more food available)
- ☑ Environment (climate, organic, etc)
- ☐ Quality (higher quality products for the customers)
- ☑ Economy (less costly products for the customer, higher revenue for the producer)
- ☑ Ergonomy & Safety (less manual work required, improved work-environment)
- ☑ Technology (to be in the front line within technology development)
- ☐ Job creation (more jobs, keeping jobs in Europe)
- ☐ Other:

agROBOfood – Technology Mapping

Introduction:

This questionnaire is used to map robotic technologies that should be used more in the agri-food sector – from planning and production to processing and transportation – both existing technologies as well as potential technologies that can be transferred from other sectors. The intent is to create better solutions for the industry – with better interfacing, re-use & standardisation. Thank you for your input and assistance!

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High-level benefit to Agri-Food domain:
Outline the value added by using this technology

This end-to-end software solution integrates all available data including multispectral footage, data from harvesters, drones, etc. to enable the best live decision making for any farmer.

What is stopping the development?
What are the technical blockers and critical risks that prevent the development from happening today?

Many farmers are not aware of the great benefit of using such software tools and are not willing to invest, despite the great potential benefits.

Description:
Describe the technology and its possible application. What steps are needed to validate it in the agri-food domain? If possible, provide figures for estimated timescale and investments required.

Our software plaform integrates all data potentially useful to farmers, starting from real-time satelite images, multispectral videos and ground data, e.g. soil samples, water analysis, etc. in a multilayer digital twin map of any field. This digital twin is used as a basis for the development of AI tools which allow for vastly improved decision making on watering, fertilization and overall crop management due to the live nature of the used data. A trial has been agreed which will validate the technology in the next 3-6 months on a 400 hectar field. After that, depending on the trial success, the technology can be scaled to any farm size rapidly, within 1-2 months, depending on the data available for the region in question.

Current status of the technology:
Please indicate in which sectors technology is used (if outside agri-food domain). Give references to existing installations, if applicable (company, location etc).

We use our software to integrate images, videos, lidar data, etc. to create interactive digital twins of the real world. We have delivered projects for Sofia Municipality including 3D mapping and digital twins for several Sofia neighbourhoods and an AI tree counting and classification tool to aid park maintenance for the municipality.

Current TRL:
TRL1 = Basic principles observed
TRL9 = Actual system proven

7

Agri-Food TRL:

4

Current providers and/or Developer/research groups:

MYX Robotics LTD

Contact details
Can we contact you for more info? If so, provide name, organisation and e-mail.

Yavor Mihailov - MYX Robotics
yavormmihailov@myxrobotics.com
+359884733472

Date / Version No.
17 April 2020

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825395

Searchable Keywords & Tags for Classification

A. Sectors

- ☐ Primary Production, Agriculture, Horticulture:
  - ☐ Greenhouse
  - ☐ Field crops (arable land)
  - ☐ Grove and woody crops
  - ☐ Aquaculture
  - ☐ Fungiculture
  - ☐ Algaculture
  - ☐ Livestock
- ☐ Food Processing:
  - ☐ Meats, Fish, etc
  - ☐ Fruits, Vegetables
  - ☐ Cereals
  - ☐ Fungus
  - ☐ Algae
  - ☐ New foods
- ☐ Logistics, Distribution:
  - ☐ Packaging
  - ☐ Transportation
  - ☐ Storage
- ☑ Customer, Market:
  - ☐ Information
  - ☐ Transparency
  - ☐ Time-to-market
  - ☐ Organic
- ☐ Other:

___

___

Instruction:

Please select as many keywords and detailed tags as possible; it will make it easier for others to locate this suggestion when searching.

B. Processes

- ☑ Crops, Plants:
  - ☐ Preparing, Seeding, Seedlings
  - ☐ Replanting
  - ☐ Watering
  - ☐ Fertilising
  - ☐ Pollinating
  - ☐ Weeding, Spraying
  - ☐ Mowing
  - ☐ Pruning
  - ☐ Monitoring
  - ☐ Harvesting
  - ☐ Transporting
- ☐ Livestock:
  - ☐ Insemination
  - ☐ Birthing
  - ☐ Feeding
  - ☐ Cleaning
  - ☐ Milking
  - ☐ Shearing
  - ☐ Searching
  - ☐ Vaccinating
  - ☐ Transporting
- ☐ Primary Processing:
  - ☐ Drying
  - ☐ Threshing, Winnowing
  - ☐ Milling
  - ☐ Shelling
  - ☐ Butchering
  - ☐ Deboning
  - ☐ Cutting
  - ☐ Freezing
  - ☐ Smoking
  - ☐ Pressing, Extracting
  - ☐ Filtering
  - ☐ Canning
  - ☐ Homogenizing
  - ☐ Pasteurizing
  - ☐ Packaging
  - ☐ Transporting
- ☐ Secondary Processing:
  - ☐ Comminution
  - ☐ Fermenting
  - ☐ Baking
  - ☐ Cooking
  - ☐ Transporting
- ☐ Other:

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C. Products

- ☐ Livestock:
  - ☐ Cattle
  - ☐ Poultry
  - ☐ Pig
  - ☐ Goat
  - ☐ Sheep
  - ☐ Fish
- ☑ Grains & Field Crops:
  - ☐ Barley
  - ☐ Wheat
  - ☐ Maize/Corn
  - ☐ ___
- ☑ Fruits:
  - ☐ Grapes
  - ☐ Apples & Pears
  - ☐ Berries
  - ☐ ___
- ☑ Vegetables:
  - ☐ Salad
  - ☐ Tomatoes
  - ☐ ___
- ☑ Plants:
  - ☐ Roses
  - ☐ Tulips
  - ☐ ___
- ☐ Animal Products:
  - ☐ Milk
  - ☐ Meat
  - ☐ Eggs
  - ☐ ___
- ☑ "Data":
  - ☐ Growth info
  - ☐ Health info
  - ☐ ___
- ☐ Other:

___

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D. Technologies

- ☑ Robot Technologies
  - ☐ Vision
  - ☐ Control
  - ☐ Path planning
  - ☐ Navigation
  - ☐ Safety
  - ☐ Connectivity
  - ☐ Data analytics
  - ☐ Grippers/Grasping
  - ☐ ___
- ☐ Robot Type, Platform:
  - ☐ Mobile robot
  - ☐ Manipulator
  - ☑ Drone
  - ☐ Retrofit to existing vehicle
  - ☐ ___
- ☑ Software:
  - ☐ Digital twinning
  - ☐ Simulation
  - ☐ Integration
  - ☐ ___
- ☐ Other:

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E. Value Drivers

- ☐ Nutrition (more food available)
- ☐ Environment (climate, organic, etc)
- ☐ Quality (higher quality products for the customers)
- ☑ Economy (less costly products for the customer, higher revenue for the producer)
- ☑ Ergonomy & Safety (less manual work required, improved work-environment)
- ☑ Technology (to be in the front line within technology development)
- ☐ Job creation (more jobs, keeping jobs in Europe)
- ☐ Other:

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agROBOfood – Technology Mapping

Introduction:

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High-level benefit to Agri-Food domain:

Outline the value added by using this technology

Reducing soil compaction preserves the soil for future generations. Continuous autonomous weeding prevents young plants being out-competed by weeds and prevents weeds getting established. Higher yields for reduced financial outlay and labour. Scalability. FarmDroid has been calculated to offer a 80% savings on organic beet and rapeseed and 60% on non-organic beet and rapeseed.

What is stopping the development?

What are the technical blockers and critical risks that prevent the development from happening today?

Nothing - development is ongoing and production is currently keeping pace with sales.
We are at the point where we need to secure faster production methods, but for that we need a larger customer and distributor base

Description:

Describe the technology and its possible application. What steps are needed to validate it in the agri-food domain? If possible, provide figures for estimated timescale and investments required.

FarmDroid is an innovative field robot that helps farmers and plant growers reduce the costs for sowing and weeding of crops while keeping it CO_2 neutral and organic. The FarmDroid FD20 is a startling invention for agriculture; an autonomous lightweight field robot that automates sowing and weed removal on farmland. This means that the soil is grown organic, CO_2-neutral and without the risk of causing structural damage from heavy equipment

Current status of the technology:

Please indicate in which sectors technology is used (if outside agri-food domain). Give references to existing installations, if applicable (company, location etc).

The robot has been field tested for over 8 years on beet and rapeseed on relatives' fields and the first customers that signed up have received their robot. Real-life tests in these operational environments have started

Current TRL:

TRL1 = Basic principles observed
TRL9 = Actual system proven

8/9

Agri-Food TRL:

8/9

Current providers and/or Developer/research groups:

Farmdroid A/S

Contact details

Can we contact you for more info? If so, provide name, organisation and e-mail.

Date / Version No.

28th April 2020

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825395

Searchable Keywords & Tags for Classification

A. Sectors

- [ ] Primary Production, Agriculture, Horticulture:
  - [ ] Greenhouse
  - [x] Field crops (arable land)
  - [ ] Grove and woody crops
  - [ ] Aquaculture
  - [ ] Fungiculture
  - [ ] Algaculture
  - [ ] Livestock
- [ ] Food Processing:
  - [ ] Meats, Fish, etc
  - [ ] Fruits, Vegetables
  - [ ] Cereals
  - [ ] Fungus
  - [ ] Algae
  - [ ] New foods
- [ ] Logistics, Distribution:
  - [ ] Packaging
  - [ ] Transportation
  - [ ] Storage
- [ ] Customer, Market:
  - [ ] Information
  - [ ] Transparency
  - [ ] Time-to-market
  - [x] Organic

- [ ] Other:

Instruction:

Please select as many keywords and detailed tags as possible; it will make it easier for others to locate this suggestion when searching.

B. Processes

- [ ] Crops, Plants:
  - [x] Preparing, Seeding, Seedlings
  - [ ] Replanting
  - [ ] Watering
  - [ ] Fertilising
  - [ ] Pollinating
  - [x] Weeding, Spraying
  - [ ] Mowing
  - [ ] Pruning
  - [ ] Monitoring
  - [ ] Harvesting
  - [ ] Transporting
- [ ] Livestock:
  - [ ] Insemination
  - [ ] Birthing
  - [ ] Feeding
  - [ ] Cleaning
  - [ ] Milking
  - [ ] Shearing
  - [ ] Searching
  - [ ] Vaccinating
  - [ ] Transporting
- [ ] Primary Processing:
  - [ ] Drying
  - [ ] Threshing, Winnowing
  - [ ] Milling
  - [ ] Shelling
  - [ ] Butchering
  - [ ] Deboning
  - [ ] Cutting
  - [ ] Freezing
  - [ ] Smoking
  - [ ] Pressing, Extracting
  - [ ] Filtering
  - [ ] Canning
  - [ ] Homogenizing
  - [ ] Pasteurizing
  - [ ] Packaging
  - [ ] Transporting
- [ ] Secondary Processing:
  - [ ] Comminution
  - [ ] Fermenting
  - [ ] Baking
  - [ ] Cooking
  - [ ] Transporting
- [ ] Other:

C. Products

- [ ] Livestock:
  - [ ] Cattle
  - [ ] Poultry
  - [ ] Pig
  - [ ] Goat
  - [ ] Sheep
  - [ ] Fish
- [x] Grains & Field Crops:
  - [ ] Barley
  - [ ] Wheat
  - [x] Maize/Corn
  - [x] beet, rapeseed
- [ ] Fruits:
  - [ ] Grapes
  - [ ] Apples & Pears
  - [ ] Berries
  - [ ]
- [ ] Vegetables:
  - [ ] Salad
  - [ ] Tomatoes
  - [ ]
- [ ] Plants:
  - [ ] Roses
  - [ ] Tulips
  - [ ]
- [ ] Animal Products:
  - [ ] Milk
  - [ ] Meat
  - [ ] Eggs
  - [ ]
- [ ] "Data":
  - [ ] Growth info
  - [ ] Health info
  - [ ]

- [ ] Other:

D. Technologies

- [ ] Robot Technologies
  - [ ] Vision
  - [x] Control
  - [ ] Path planning
  - [x] Navigation
  - [ ] Safety
  - [ ] Connectivity
  - [ ] Data analytics
  - [ ] Grippers/Grasping
  - [x] mechanical hoe
- [ ] Robot Type, Platform:
  - [x] Mobile robot
  - [ ] Manipulator
  - [ ] Drone
  - [ ] Retrofit to existing vehicle
  - [ ]
- [ ] Software:
  - [ ] Digital twinning
  - [ ] Simulation
  - [ ] Integration
  - [ ]

- [x] Other:

precise RTK-GPS with base station

E. Value Drivers

- [ ] Nutrition (more food available)
- [x] Environment (climate, organic, etc)
- [ ] Quality (higher quality products for the customers)
- [x] Economy (less costly products for the customer, higher revenue for the producer)
- [ ] Ergonomy & Safety (less manual work required, improved work-environment)
- [ ] Technology (to be in the front line within technology development)
- [ ] Job creation (more jobs, keeping jobs in Europe)

- [ ] Other:

agROBOfood – Technology Mapping

Introduction:

This questionnaire is used to map robotic technologies that should be used more in the agri-food sector – from planning and production to processing and transportation – both existing technologies as well as potential technologies that can be transferred from other sectors. The intent is to create better solutions for the industry – with better interfacing, re-use & standardisation. Thank you for your input and assistance!

Please fill out separate copies of this document with only one technology reported per saved PDF-file.
Submit your contribution to the technology mapping by Apr 1 2020. Send by e-mail to rhk@dti.dk

High-level benefit to Agri-Food domain:	What is stopping the development?
Outline the value added by using this technology	What are the technical blockers and critical risks that prevent the development from happening today?
Reduce manual / labour intensive frequent checking when birthing event is close. Avoid risk of missing a birthing event with complications whereby intervention is needed.	This technology is used and available in the market today. However, adoption levels of this kind of technology could be much higher. Blockers include low levels of comfort with technology for some demographics and lack of awareness and access to trining.

Description:

Describe the technology and its possible application. What steps are needed to validate it in the agri-food domain? If possible, provide figures for estimated timescale and investments required.

Calving sensors - devices fitted on tail of animals close to birthing. Contractions/ tail movements monitored. Notification sent when birthing event is imminent.

Current status of the technology:	Current TRL:
Please indicate in which sectors technology is used (if outside agri-food domain). Give references to existing installations, if applicable (company, location etc).	TRL1 = Basic principles observed TRL9 = Actual system proven
Technology currently used in farming.	TRL8
	Agri-Food TRL:
	TRL8

Current providers and/or Developer/research groups:

e.g. Moocall

Contact details	Date / Version No.
Can we contact you for more info? If so, provide name, organisation and e-mail.	
Christine O'Meara comeara@tssg.org	

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825395

Searchable Keywords & Tags for Classification

A. Sectors

- ☐ Primary Production, Agriculture, Horticulture:
  - ☐ Greenhouse
  - ☐ Field crops (arable land)
  - ☐ Grove and woody crops
  - ☐ Aquaculture
  - ☐ Fungiculture
  - ☐ Algaculture
  - ☐ Livestock
- ☐ Food Processing:
  - ☐ Meats, Fish, etc
  - ☐ Fruits, Vegetables
  - ☐ Cereals
  - ☐ Fungus
  - ☐ Algae
  - ☐ New foods
- ☐ Logistics, Distribution:
  - ☐ Packaging
  - ☐ Transportation
  - ☐ Storage
- ☐ Customer, Market:
  - ☐ Information
  - ☐ Transparency
  - ☐ Time-to-market
  - ☐ Organic

☐ Other:

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Instruction:

Please select as many keywords and detailed tags as possible; it will make it easier for others to locate this suggestion when searching.

B. Processes

- ☐ Crops, Plants:
  - ☐ Preparing, Seeding, Seedlings
  - ☐ Replanting
  - ☐ Watering
  - ☐ Fertilising
  - ☐ Pollinating
  - ☐ Weeding, Spraying
  - ☐ Mowing
  - ☐ Pruning
  - ☐ Monitoring
  - ☐ Harvesting
  - ☐ Transporting
- ☐ Livestock:
  - ☐ Insemination
  - ☐ Birthing
  - ☐ Feeding
  - ☐ Cleaning
  - ☐ Milking
  - ☐ Shearing
  - ☐ Searching
  - ☐ Vaccinating
  - ☐ Transporting
- ☐ Primary Processing:
  - ☐ Drying
  - ☐ Threshing, Winnowing
  - ☐ Milling
  - ☐ Shelling
  - ☐ Butchering
  - ☐ Deboning
  - ☐ Cutting
  - ☐ Freezing
  - ☐ Smoking
  - ☐ Pressing, Extracting
  - ☐ Filtering
  - ☐ Canning
  - ☐ Homogenizing
  - ☐ Pasteurizing
  - ☐ Packaging
  - ☐ Transporting
- ☐ Secondary Processing:
  - ☐ Comminution
  - ☐ Fermenting
  - ☐ Baking
  - ☐ Cooking
  - ☐ Transporting
- ☐ Other:

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C. Products

- ☐ Livestock:
  - ☐ Cattle
  - ☐ Poultry
  - ☐ Pig
  - ☐ Goat
  - ☐ Sheep
  - ☐ Fish
- ☐ Grains & Field Crops:
  - ☐ Barley
  - ☐ Wheat
  - ☐ Maize/Corn
  - ☐ ______________
- ☐ Fruits:
  - ☐ Grapes
  - ☐ Apples & Pears
  - ☐ Berries
  - ☐ ______________
- ☐ Vegetables:
  - ☐ Salad
  - ☐ Tomatoes
  - ☐ ______________
- ☐ Plants:
  - ☐ Roses
  - ☐ Tulips
  - ☐ ______________
- ☐ Animal Products:
  - ☐ Milk
  - ☐ Meat
  - ☐ Eggs
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- ☐ "Data":
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☐ Other:

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D. Technologies

- ☐ Robot Technologies
  - ☐ Vision
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  - ☐ Digital twinning
  - ☐ Simulation
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☐ Other:

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E. Value Drivers

- ☐ Nutrition
  (more food available)
- ☐ Environment
  (climate, organic, etc)
- ☐ Quality
  (higher quality products for the customers)
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  (less costly products for the customer, higher revenue for the producer)
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- ☐ Job creation
  (more jobs, keeping jobs in Europe)

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High-level benefit to Agri-Food domain:	What is stopping the development?
Outline the value added by using this technology Robotics milking systems free up farmers time significantly (up to 5 hours a day) which enables them to focus on strategic aspects of their business. Furthermore robotic systems enable farmers to maximise output, facilitating the milking of high-yielding cows more than once per day. Herds can be managed more effectively by splitting them into high yielding and low yielding groups and managing diet accordingly.	What are the technical blockers and critical risks that prevent the development from happening today? Adoption is increasing however cost is a significant deterrent. Robotic systems cost as much as 3 x times more than traditional systems.

Description:
Describe the technology and its possible application. What steps are needed to validate it in the agri-food domain? If possible, provide figures for estimated timescale and investments required. Technology Robotic milking units house animals for milking process, clean teats, attach automatically and self attach. Cups are removed based on flow to prevent over milking. Animals are fitted with electronic identifier tags which are used to track yield. Other features can include feeding, animal brushing and facility cleaning.

Current status of the technology:	Current TRL:
Please indicate in which sectors technology is used (if outside agri-food domain). Give references to existing installations, if applicable (company, location etc). Well developed and continuously evolving technology	TRL1 = Basic principles observed TRL9 = Actual system proven TRL9 **Agri-Food TRL:** TRL9
Current providers and/or Developer/research groups: Several including LELY	

Contact details	Date / Version No.
Can we contact you for more info? If so, provide name, organisation and e-mail.	

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