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D2.6 Industry & end users needs



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3	FUNDACIO EURECAT	EUT	ES
4	FONDACIJA VIZLORE LABS	VLF	SRB
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1 Introduction

This report forms part of WP2 ‘Ecosystem Mapping & Training’. describes the steps and actions performed in” Task 2.1 User requirements and measurable metrics” during the first 18 months of the project and can be considered as a key input for the definition of the use cases and application scenarios (T5.1). The requirements analysis (D 2.1) built the foundation for the concrete specification of the data infrastructure, the robotic platform, and the implement (sprayer). At this initial stage of WP2, focus was placed on determining use cases in apple and wheat crops from the perspective of various spraying manufacturers and solution end-users with the aim to cover most customer needs.

To this end, Cluster FEMAC designed a relevant questionnaire in collaboration with partners AGRIFOOD LTH, Agricultural University of Athens (AUL); Wageningen University; Agreenculture, EURECAT, and AGROMA. Respecting the need for seamless Direct Injection Systema, set as a goal for SMART DROPLETS, key information to be collected related to spraying machinery techolgies, data formats and data protocols. In SMART DROPLETS, spraying machinery manufacturers play a big role in this digital ecosystem and significantly influence the sector with their innovations. Therefore, all information obtained from this survey is useful in defining the technical aspects of machine interoperability throughout the project.

1.1 Aim

This SMART DROPLETS Report aims to collect and report back on the machine manufacturers’ and end users’ technical requirements, which once met, will enable to give a systematic formalization of a set of relevant specifications, necessary to the deployment of the two pilot’s projects. Specifically, the goal of the deliverable is to define a list of requirements for the technical work in WP3 & WP4 and serve as the prerequisites for pilot planning in WP5.

1.2 Partners involved.

Partners Cluster FEMAC, AgriFood Lithuania DIH (AFL), Agricultural University of Athens (AUA), worked together to develop the questionnaire for the machine manufacturers’ survey. Cluster FEMAC has expertise in the agricultural machinery sector, and it knows well the main Spanish Players provided valuable input for the development of this survey.

AUA contributed with their scientific expertise in the field of control technology of agricultural machines. Partner Fondacija Vizlore Labs supported the creation of the questionnaire with their expertise in software development. Partner AGROMA SA contributed with their expertise in manufacturing spraying machines, and Fundació EURECAT, in programming interfaces (APIs). Finally, partner AGREENCULTURE brought their knowledge of robotic systems integration.



2 Methodology

2.1 Type of survey

The survey on ‘Spraying Machine Manufacturer Requirements’ and “End-User Requirements” were a one-off online survey to collect technical requirements for the knowledge of technical and functional requirements of Industry and end users. This was a cross-sectional online survey; responses were collected and studied partially in February/march 2023 and March 2024. The surveys were submitted with google forms. available online on the DLG e.V.¹, ATLAS² and AEF e.V.³ websites from 31st March 2020 until 15th May 2

2.2 Target Groups Selection

The surveys were designed and focused on agricultural machinery manufacturers and end users. Such companies can be broadly grouped into three categories:

- a) Manufacturers of spraying and crop protection machinery; in particular, orchard sprayers, Booma sprayers, Pneumatic sprayers, dust, and cannon. Such manufacturers have specialist knowledge of electronic on-board technologies.
- b) Manufacturers of agricultural implements; in particular, air components, pumps, plastic containers, transmission systems. Such manufacturers have the expert knowledge of machine connectivity and user-related data processing services.
- c) Manufacturers of machinery for specific types of crops; in particular, fruit, vegetables, and herbs cultivation. Such manufacturers have the detailed knowledge of precise control of implements.

And farmers growing apples and/or wheats.

Hence, in the first instance, FEMAC used own mailing lists to communicate the survey to agricultural machinery companies, both with national and international reach. In addition, FEMAC supported the dissemination of the survey to their members. ANSEMAT member companies consist mainly of machine manufacturers with both national and international reach. Therefore, the companies contacted represent a large part of the agricultural spraying machinery sector.

2.3 Data collection

2.3.1 Contact procedure

The first online survey (End users) was running from first of February until second half of March 2023, the results of which were posted in the first version of Deliverable 2.1, and once it was updated, was shift to the D.2.6 . The results of the second and the last one (To Industry) during the March 2024 it is included in the following sections. . All target groups were contacted via email. In order to maximize participation in the survey, automatic reminders were also set at a frequency of two weeks since the beginning of the survey. These reminders were also sent to participants with semi-complete surveys at the time.



Smart Droplets will engage with end users (farmers) from the outset and throughout the life of the project. Stakeholders from the agricultural sector will be in the core of the design process in multiple disciplines. First and foremost, all the sector shortcomings regarding crop protection that can be solved through a holistic automated approach will be defined by the problem owners. Based on the feedback obtained in this task, the project will focus on further activities, on proposing and designing the appropriate solution to be deployed. Stakeholders from the pilot-specific regions, Spain, and Lithuania, have been prioritized, but will not have exclusivity in the decision-making process. Relevant actors in both countries have been invited to contribute throughout the entire market chain, from farmers to technology providers that are actively promoting advancements in agricultural automation. The technical partners (AUA, WU, EUT, VLF, AGR, AGC) will provide with a well-rounded robotic system (data infrastructure, robotic platform, implementation) and operational scenarios that will help end-users to evaluate the system and contribute their suggestions, thus increasing the overall impact and avoid unnecessary and inefficient developments. Multiple showcases and interaction is foreseen across the lifecycle of the project, ensuring that public interest is maintained throughout.

Interviews with representatives of the industry have been carried out, where these manufacturers produce a range of field spraying machinery, including self-propelled sprayers, boom sprayers, and others.

The method of collecting data used was a face-to-face or phone conversation between the interviewer and the respondents. Interviews were structured, with a set of predetermined questions that were asked in the same order to each respondent, and with open-ended questions and following up on the responses of the respondent. Interviews

The aim of this deliverable is to analyze the requirements retrieved from industrial stakeholders and farmers. The requirements' capture involves the documentation of industrial and regulatory needs and opinions about new data, which will set the baseline for conducting the actual measurements during the two use case trials, for apples and for wheat. Requirements collection has been performed via electronic surveys and through dedicated workshops/interviews with the foreseen actors of every case study.

To maximize participation all, the SMART DROPLETS partners have translated the questionnaire, and it has been forwarded to their farming and industry ecosystem's guidelines for the interviews are presented in Annex I.

2.4 Weighting

No weighting was used. All responses were treated as equally significant from a statistical point of view.

2.5 Raw data

The processed raw data on all content on the individual questions are available to the SMART DROPLETS project coordination and can be viewed if necessary.



3 Results [Industry segment]

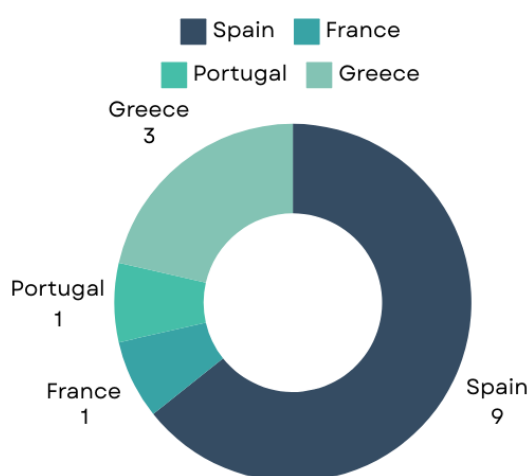
3.1 Sample Description

The main characteristics of the sample are presented in this section. In total, 14 participants contributed to this online survey. While the sample is too small to be representative of EU spraying machinery manufacturers, it does still cover a large range of spraying technological solutions. Overall, the sample covered by the study remains biased towards members of ANSEMAT and FEMAC (see Figure 1). Although this can be seen as a limiting factor for the statistical analysis of results, it also provides the clear advantage of keeping the focus on the more active and specialized spraying machine manufacturers, i.e. those who are more likely to have interest in research and development of digital farming tools. This bias, though, should be considered when interpreting the results.

3.1.1 Participants' general profile

"Please indicate your country."

This survey was sent to smart droplets consortium members to spread among its ecosystem, and specially to those who have some manufacture crop protection machinery among their industry. Out of 14 participants, 9 companies are from Spain, 3 from Greece, 1 from France and 1 from Portugal.



Understanding the geographic spread of respondents enables us to see that south of Europe there is an important spraying machinery manufacturers industry.

Figure 1: Country of origine.

"Is your company a member of a national association of agricultural machinery? Which one"

The inquiry "Is your company a member of a national association of agricultural machinery?" delves into the organizational affiliations within the agricultural machinery sector. This question serves as a pivotal lens through which we can gauge the level of industry involvement and the networks that shape it.

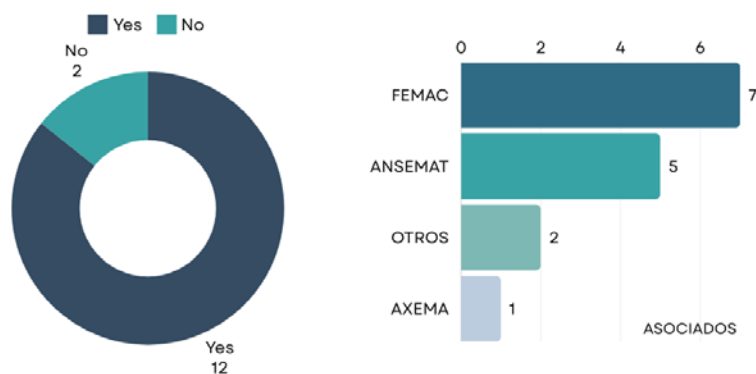


Figure 2: Professional associations

Analyzing these survey responses, out of 14 companies, 7 are members of Cluster FEMAC (Partner of SMARTDROPLETS), most of them are at the same time members of the National association ANSEMAT¹, companies of Greece have not identified which one, and the French one belongs to AXEMA².

“Have your company sprayers a Direct Injection Spraying (DIS) system is incorporated in your catalogue?”

As a result of the survey, only one company from France responds that has a Direct Injection Spraying (DIS) system is incorporated in one of the group companies' catalogues.

3.1.2 Participants' main sales markets

“In which markets does your company sell your Crop Protection Machinery?”

Interpreting the responses to this question unveils a nuanced understanding of the strategic market positioning and expansion strategies employed by companies in the agricultural spraying machinery sector. By delineating the regions and countries where crop protection machinery is sold, we can discern that as Mediterranean countries the basically sell their products in their area of influence.

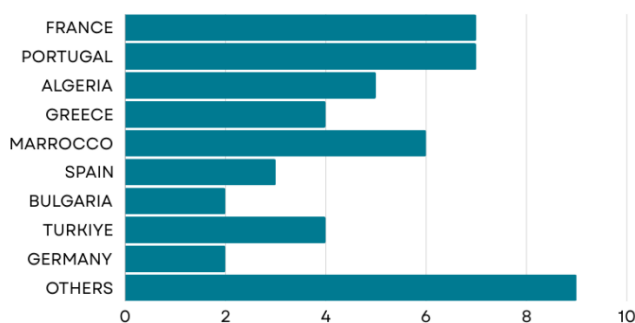


Figure 3: Target markets

3.2 Product Catalogue

“Which spraying product model(s) is your company manufacturing/selling?”

¹ <https://www.ansemat.org/>

² <https://www.axema.fr/>

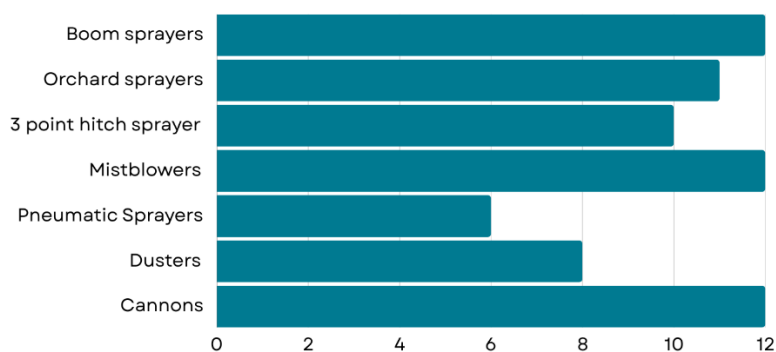


Figure 4: Spraying machines types

The result of the question "Which spraying product model(s) is your company manufacturing/selling?" indicates the distribution of different types of spraying products among the respondents. This results that 13 companies are manufacturing or selling boom sprayers. Boom sprayers are commonly used in broad-acre applications for spraying crops such as grains, oilseeds, and vegetables. They are known for their wide coverage and efficient application. 9 of 12 are involved in manufacturing or selling orchard sprayers. Orchard sprayers are specifically designed for spraying trees and vines in orchards and vineyards. They often have features such as adjustable height and narrow sprayer heads to navigate between rows of trees. The major of the, up to 10, have models of sprayers mounted on the 3-point hitch of tractors and are suitable for smaller-scale spraying operations, such as in gardens, nurseries, or small fields. All of them (12/14), considering that 2 answers are not SME, are involved in manufacturing or selling mist blowers. Mist blowers are used for applying pesticides, fungicides, or fertilizers in fine droplets, providing thorough coverage, especially in dense foliage or hard-to-reach areas. To highlight also that twelve companies are manufacturing or selling cannons. Cannons, also known as air-assisted sprayers or air blast sprayers, are used for high-volume spraying in orchards, vineyards, or tall crops. They use air to propel droplets into the canopy for better penetration and coverage.

This distribution of spraying product models among the respondents reflects the diversity of spraying equipment available in the market and suggests that companies are catering to different agricultural applications and preferences. The varying numbers across different types of sprayers also indicate the specialization and focus areas of these companies in the agricultural machinery industry.

"Which technologies are your spraying machinery equipped for?"

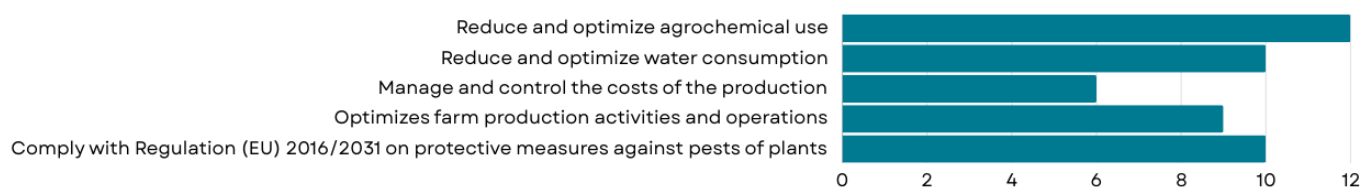


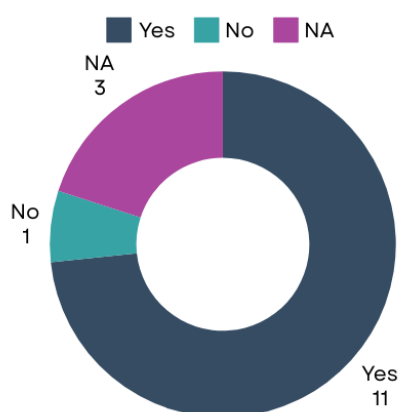
Figure 5: Technologies for

Before going into detail to the type of technologies and the functionalities and specifications, we wanted to know what the result pursuit were to introduce the new technologies to the spraying machines. The result to the question "Which technologies are your spraying machinery equipped for?" provides insights into the technological capabilities of spraying machinery in addressing various agricultural challenges and requirements. Let's see which were:

12 respondents reported that their spraying machinery is equipped with technologies aimed at reducing and optimizing agrochemical use. Such technologies may include precision application systems that deliver agrochemical precisely where needed, variable rate application systems that adjust agrochemical rates based on sensor-based systems that monitor crop needs in real-time to optimize phytosanitary usage. Ten respondents stated that their spraying machinery is equipped with technologies focused on reducing and optimizing water consumption. Six respondents indicated that their spraying machinery is equipped with technologies aimed at managing and controlling production costs. These technologies may encompass features such as efficiency monitoring systems that track input usage, automated control systems that optimize operational costs, or data analytics tools that identify cost-saving opportunities within the production process. Nine respondents reported that their spraying machinery is equipped with technologies that optimize farm production activities and operations. These technologies could include integrated farm management software that streamlines planning and execution, automation systems that improve workflow efficiency, or connectivity solutions that enable real-time monitoring and decision-making. Ten respondents mentioned that their spraying machinery is equipped to comply with Regulation (EU) 2016/2031 on protective measures against pests of plants. This regulation sets standards for the safe and sustainable use of plant protection products. Technologies for compliance may include application rate control systems, drift reduction technologies, or record-keeping features to ensure adherence to regulatory requirements.

As a conclusion, the result indicates that spraying machinery manufacturers are incorporating various technologies to address key agricultural challenges such as resource efficiency, cost management, regulatory compliance, and operational optimization. These technological advancements play a vital role in promoting sustainability, productivity, and competitiveness in modern agriculture.

“Is it possible to digitally connect own spraying machines with Farm Management Information Software from other software developers?”



11 companies answered yes, one company said was not possible “yet”, and 2 others not applied. During the follow up answers mayor entrepreneurs and technicians highlight

“Integrating spraying machines with Farm Management Information Software (FMIS) streamlines data exchange, enhancing the efficiency of managing spraying schedules, application rates, and inventory, and farmers can monitor spraying operations in real-time, adjusting parameters for better control and effectiveness.”

“Due the compliance and documentation if new EU regulations, Integration ensures compliance with regulations by maintaining accurate records of spraying activities and pesticide usage”.

Figure 6: Farm Management Information Software

“Have your company sprayers a Direct Injection Spraying (DIS) system is incorporated in your catalogue?”

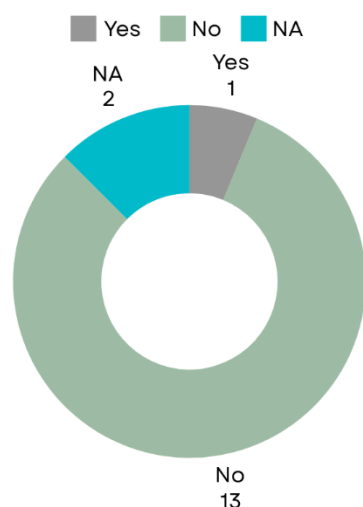


Figure 7: DIS System

13 companies answered no, one company said was possible to offer this technology to their clients, and 2 others not applied. During the follow up answers mayor entrepreneurs and technicians highlight:

“This technology is technically appreciated as a clean method to reduce operator exposure and leftover chemical mixtures.”

“It is necessary that DIS technology be affordable and adoptable in the context of small scale farming.”

“Has your company worked in Track guidance system?”

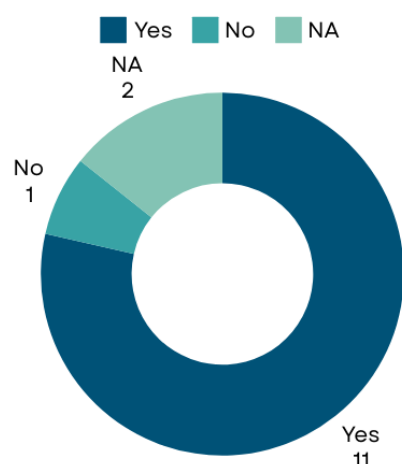


Figure 8: Track Guide System

11 companies have confirmed that they have worked with track guidance systems. This could involve various levels of engagement, such as development, implementation, or utilization of track guidance technology in their products or services. One company explicitly stated that they have not worked with track guidance systems.

Overall, the responses reflect a range of experiences and engagements with track guidance systems among the surveyed companies, with a majority affirming their involvement, one explicitly stating no involvement, and two indicating that the question didn't apply to them.

“In your opinion which are the main functional requirements needed for this system?”

The question "In your opinion, what are the main functional requirements needed for this system?" is likely asked to gather insights and perspectives on the essential features and capabilities that stakeholders believe a track guidance system should possess. Here's why this question is important and the reasons behind asking it:

Understanding Industry Needs: Different stakeholders, such as farmers, agricultural engineers, software developers, and researchers, may have varying perspectives on what functionalities are crucial for a track guidance system. By asking for Industry opinions, it helps in understanding the diverse needs and priorities of these spraying machinery manufacturers. Responses to this question

will provide valuable input for designing and developing track guidance systems for the smart droplet system. Understanding the functional requirements from the perspective of industry and experts helps in creating systems that are aligned with their needs and expectations. The answer also we will help to highlight specific features or functionalities they consider indispensable for the effective operation of a track guidance system. These insights help in prioritizing the development efforts and ensuring that the system includes the most critical features.

Overall, asking for opinions on the main functional requirements of a track guidance system serves to gather valuable insights that inform the design, development, and improvement of the system, ultimately aiming to meet the diverse needs and expectations of users in the industry sector.

As we can see to the following answers we might realize, whether they have or not a track guidance system, which are the main functionalities needed for the system.

Table 1: functional requirements needed for Track guidance system answers

Questions	Answers	Requirement
1. Every measurement must come with a timestamp to give the displaying system the possibility to show the user when the measurement was taken. <i>It ensures that users have access to timely and contextually relevant information, enhancing their ability to interpret and utilize measurement data effectively within the system.</i>	11	F1
2. Every measurement must come with a timestamp to give the displaying system the possibility to show the user when the measurement was taken. <i>It mandates that each piece of data collected or measured within the system must be accompanied by a timestamp indicating the exact time at which the measurement was taken.</i>	11	F2
3. Every measurement should include speed, pesticide tank level, water level, and engine state as a foundational set to fulfill the machine tracking use-case effectively. It outlines specific parameters that should be included in every measurement taken by the system	11	F3
4. The system shall support a functionality which allows the user to access historical data: <i>It underscores the importance of providing users with the capability to retrieve past data records stored within the system</i>	10	F4
5. The system must ensure that only the owner can give access to the machine data. <i>This ensures that the system implements robust access control mechanisms to safeguard machine data, protect privacy, and maintain data integrity and confidentiality, while empowering owners to manage access permissions effectively</i>	12	F5
6. The system must offer a designated unit of measure for each attribute to ensure accurate display of the information. <i>It ensures that the system provides a user-friendly and reliable interface for displaying attribute data with designated units of measurement, promoting accuracy, consistency, and clarity in data presentation and interpretation</i>	6	F6
7. The system shall provide the measurement rate, unit, and bit resolution for every attribute (in reference to ISO 11783 ³). <i>It outlines specific specifications for data representation and communication within the system, aligning with the standards set forth by ISO 11783</i>	4	F7
8. The system shall be able to limit the accessibility of a machine to a certain timeframe. <i>It pertains to implementing controls within the system that restrict access to a machine within specific time periods</i>	5	F8
9. The system shall provide a functionality to search and add a machine to the used system to receive telemetry data. <i>It outlines the need for a</i>	10	F9

³ ISO 11783 is a standard that specifies a communication protocol for the exchange of data between electronic control units (ECUs) on agricultural machinery.

<i>feature within the system that allows users to search for and add machines to the system for the purpose of receiving telemetry data.</i>		
10. The hosting system of the connected equipment should provide information about the supported capabilities. It refers to the system's ability to communicate to connected equipment and provide details regarding the features and functionalities it supports	5	F10
11. The system shall provide a means to uniquely identify a machine to simplify the process of machine identification for the end-user. It refers to the importance of having a method within the system to assign distinct identifiers to individual machines	6	F11
12. The system must be able to cope with the fact that the machine might not be 100% available in the network. (Can end in e.g. data bursts or missing points in between etc.). <i>It addresses the need for the system to gracefully handle situations where the machine, or the data it transmits, may not be consistently or continuously available on the network.</i>	6	F12

“In your opinion which are the main technical requirements needed for this system?”

The question "In your opinion, what are the main technical requirements needed for this system?" seeks insights into the fundamental technical specifications and capabilities that respondents believe are essential for a Track guidance system.

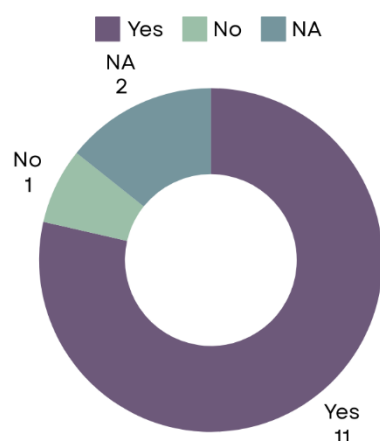
Asking for opinions on the main technical requirements of a system serves to gather valuable insights that inform the design, development, and implementation processes. By understanding Industry' perspectives on technical needs, SMART DROPLETS (WP -2) can create systems that are robust, reliable, and aligned with users' expectations.

Table 2: Technical requirements needed for Track guidance system answers.

Questions	Answers	Requirement
1. The system shall provide a means to uniquely identify a machine to simplify the process of machine identification for the end-user. <i>This requirement emphasizes the necessity for the system to offer a method of distinguishing each machine uniquely.</i>	10	T1
2. The sending system shall buffer the tracking data for a limited time in case the recipient endpoint is temporarily not able to receive them. <i>it highlights the necessity for the system to store tracking data temporarily if the intended recipient is unable to receive it immediately.</i>	8	T2
3. The system shall support the listing of available endpoints to allow configuration for the equipment owner. <i>It emphasizes the system's capability to provide a list of available endpoints that can be configured by the equipment owner</i>	10	T3
4. The tracking data sending endpoint shall provide authentication information to the receiving endpoint, to verify if the sending endpoint is allowed to send data to the receiver. <i>It refers to the need for authentication mechanisms between endpoints involved in transmitting tracking data</i>	7	T4
5. The tracking data must come with the information about the sending endpoint (the source of the transmission), to enable the receiving endpoint to identify the equipment the tracking data is coming from. <i>It specifies that tracking data must include details about the sending endpoint, allowing the receiving endpoint to identify the equipment from which the data originated</i>	8	T5
6. The system shall use standard data formats to exchange tracking data. <i>It specifies that the system must utilize established and widely recognized</i>	10	T6

	<i>formats for the exchange of tracking data between different components or endpoints</i>		
7.	The system shall be able to uniquely identify endpoints. <i>It specifies that the system must have the capability to assign unique identifiers to each endpoint within its network</i>	4	T7
8.	The system shall support a functionality to send tracking data to a specific endpoint (endpoint could be a machine, a group of machines or any other software system). <i>It specifies that the system must be capable of directing tracking data to a designated destination within its network.</i>	4	T8
9.	The system shall support a functionality to receive tracking data from a specific endpoint. <i>This requirement entails that the system must have the capability to direct tracking data to a specific endpoint, whether it's an individual machine, a group of machines, or any other software system within the network.</i>	4	T9

“Have your spraying machines an online task management system?”



These responses indicate that most of the companies surveyed have implemented an online task management system for their spraying machines. An online task management system enables companies to remotely schedule, track, and manage tasks related to spraying operations. This system may include features such as task scheduling, assignment of spraying activities, monitoring of progress, and data reporting capabilities accessible via an online platform. Companies that have adopted such systems likely benefit from enhanced efficiency, coordination, and oversight of their spraying operations.

Figure 9:task management system

“In your opinion which are the main functional requirements needed for this system?”

The question "In your opinion, which are the main functional requirements needed for an online task management system?" is asked in order to understanding the main functional requirements from the perspective of technicians and industry that ensures that the online task management system is designed to meet their needs effectively. Overall, asking for opinions on the main functional requirements for an online task management system is an essential step in the requirements gathering process. It helps ensure that the system is designed to meet users' needs effectively, aligns with stakeholders' expectations, and provides a user-friendly and efficient solution for managing tasks online.

Table 3:functional requirements needed for task management system answers

Questions	Answers	Requeriment
1. The user should have the capability to dispatch a Task Batch from their preferred agricultural software directly to the spraying machine. <i>It</i>	11	F13

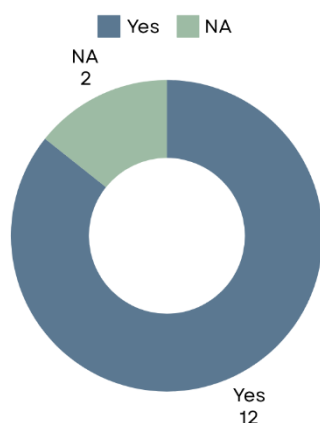
<i>outlines a functionality where users can send a batch of tasks or instructions from their preferred agricultural software directly to a spraying machine.</i>		
2. The user must be capable of receiving the Task Batch results from the spraying machine within their chosen agricultural software. <i>It highlights the necessity for users to receive feedback or results from the spraying machine within their preferred agricultural software.</i>	11	F14
3. The machine owner shall be able to define the agricultural software to exchange the Task Batch data with. It emphasizes the machine owner's ability to specify which agricultural software systems will exchange task batch data with the spraying machines.	8	F15
4. The user of the agricultural software shall be able to select the explicit machines to send the Task Batch to. <i>It specifies a functionality within the agricultural software that allows users to choose specific spraying machines to receive a task batch.</i>	8	F16
5. The user of the agricultural software must be able to clearly understand from which machine the Task Batch is coming from. <i>It emphasizes the importance of providing clear and transparent information to users regarding the source of task batches within the agricultural software.</i>	10	F17
6. The user of the machine must be able to clearly understand from which agricultural software the Task Batch is coming from. <i>It highlights the necessity for users operating the spraying machine to have clear visibility into the source of task batches received by the machine</i>	11	F18
7. The user of the agricultural software shall be able to verify if a specific machine is able to exchange Task Batch data. <i>It underscores the importance of enabling users to confirm whether a particular machine has the capability to send and receive task batch data.</i>	9	F19
8. The user of the machine or of the agricultural software must be informed about the availability of a new Task Batch	9	F20
9. Standard data formats shall be used to exchange the Task Batch data. <i>It emphasizes the adoption of standardized data formats for the exchange of task batch data between the agricultural software and the spraying machine</i>	7	F21
10. The Task Batch data shall be exchanged only among allowed agricultural software and machines. <i>It emphasizes the necessity of implementing access control mechanisms to restrict the exchange of task batch data exclusively between authorized agricultural software systems and spraying machines</i>	8	F22
11. The Task Batch data exchange must be protected to avoid unwanted data corruption and to assure data privacy. <i>It underscores the importance of implementing measures to safeguard the integrity and privacy of task batch data during exchange between agricultural software systems and spraying machines.</i>	10	F23
12. The user of the machine or of the agricultural software must be clearly informed about the status of the Task Batch data transfer (in case of problems during transmission). <i>It highlights the necessity of providing clear and timely notifications to users regarding the status of task batch data transfers between the agricultural software and spraying machines.</i>	10	F24
13. The user shall be able to see the task status on the machine. <i>It ensures that users operating the spraying machine have access to real-time information about the status of tasks directly from the machine itself.</i>	10	F25

“In your opinion which are the main technical requirements needed for this system?”*Table 4: Technical requirements needed for task management system answers*

Questions	Answers	Requirement
1. The system shall support a functionality to send Task Batch data to a specific endpoint (endpoint could be a machine, a group of machines or an agricultural software. <i>It highlights the need for the system to facilitate the transmission of task batch data to designated destinations within the agricultural ecosystem</i>	8	T6
2. The system shall support a functionality to receive Task Batch data from a specific endpoint. <i>It specifies the system's capability to accept task batch data from designated sources within the agricultural ecosystem</i>	8	T7
3. The system shall provide a means to identify in a unique way the endpoints. <i>It emphasizes the necessity for the system to establish distinctive identifiers for each endpoint within the agricultural ecosystem</i>	6	T8
4. The system shall support a functionality to check the Task Batch data exchange capability of an endpoint. <i>IT specifies the system's capability to assess and verify an endpoint's ability to send or receive task batch data within the agricultural ecosystem.</i>	6	T9
5. The system needs to cope with the fact that one Task Batch (or its subpart) can be sent to many endpoints. <i>It underscores the system's capability to handle scenarios where a single task batch or its components are distributed to multiple endpoints within the agricultural ecosystem.</i>	10	T10
6. The system shall use standard data formats to exchange the Task Batch data. <i>It emphasizes the adoption of standardized formats for the exchange of task batch data between different components within the agricultural ecosystem.</i>	10	T11
7. The system shall ensure that Task Batch data are exchanged only among granted endpoints. <i>It emphasizes the necessity of implementing access control mechanisms to restrict the exchange of task batch data to authorized endpoints within the agricultural ecosystem.</i>	11	T12
8. The Task Batch data must come with the information about the receiving endpoint (the recipient of the transmission). <i>It underscores the necessity for task batch data to include metadata identifying the specific endpoint or endpoints intended to receive the transmitted data.</i>	9	T13
9. The Task Batch data has to come with the information about the sending endpoint (the source of the transmission), to let the receiver to identify the equipment the Task Batch data are coming from. <i>to let the receiver identify the equipment the Task Batch data are coming from" emphasizes the importance of including metadata within the task batch data to identify the originating endpoint or equipment.</i>	9	T14
10. The Task Batch data has to come with the authentication token of the sending endpoint, in order to let the receiver to verify if the sending endpoint is allowed to send data to it. <i>Emphasizes the importance of including authentication tokens within task batch data to verify the legitimacy and authorization of the sending endpoint.</i>	8	T15
11. The receiving endpoint shall verify if it is the correct recipient of the Task Batch, to accept or refuse it. <i>It outlines the responsibility of the receiving endpoint to validate whether it is the intended recipient of the transmitted task batch data.</i>	10	16

12. The system shall support a functionality to inform the endpoint about the availability of new Task Batch. <i>It specifies the system's capability to notify endpoints when new task batches are available for processing</i>	12	T17
13. The system shall support a functionality to let the owner of the machine that perform the task to select the endpoints the Task Batch results will be sent back to. <i>It highlights the system's capability to enable machine owners to choose specific endpoints to which the results of a task batch will be transmitted.</i>	12	T18
14. The system shall support a functionality to configure the list of available endpoints. This functionality must include mechanisms of account pairing and granting access to the specific endpoints. <i>It refers to the system's capability to enable users to manage and customize the list of endpoints available for data exchange</i>	12	T19
15. The system shall support a functionality to inform the sending endpoint about the results of data transmission over the network. <i>It outlines the system's capability to provide feedback to the sending endpoint regarding the outcome of data transmission processes.</i>	10	T20
16. The system shall provide clear and common error messages or acknowledge messages, in order to implement a proper management of Task Batch data transfer. <i>It emphasizes the importance of effective communication between system components during the transfer of Task Batch data.</i>	8	T21
17. The system shall provide a means to buffer the Task Batch data, in case the recipient endpoint is temporarily not able to receive them. <i>It highlights the system's capability to temporarily store Task Batch data when the intended recipient endpoint is unavailable.</i>	8	T22

"Have your spraying machines an Infield sensor connection system?"



The result indicates that all 12 respondents answered affirmatively to the question "Have your spraying machines an Infield sensor connection system?" This means that all of the spraying machines associated with these respondents are equipped with an infield sensor connection system. The 12 affirmative response suggests that the use of infield sensor connection systems is widespread among the spraying machinery manufacturers.

Figure 10: Sensor connection system

"In your opinion which are the main functional requirements needed for this system?"

The question serves as a means to elicit requirements directly from individuals who have expertise or experience in the field of infield sensor connection systems. By soliciting their opinions, the question helps identify and prioritize key functionalities based on real-world needs and practical considerations.

Understanding the functional requirements from the perspective of potential users or stakeholders is crucial for designing a system that meets their needs and expectations. By asking for opinions, the

question ensures that the design process is user-centric, with functionalities tailored to address specific use cases and challenges encountered in infield sensor connections.

Different stakeholders may have varied perspectives on the functional requirements of an infield sensor connection system based on their roles, responsibilities, and areas of expertise. By soliciting opinions from a diverse range of individuals, the question allows for the consideration of multiple viewpoints, which can lead to a more comprehensive and robust set of functional requirements.

Stakeholders may prioritize certain functionalities over others based on their importance, feasibility, or potential impact on system performance. By asking for opinions, the question helps identify and prioritize key functionalities that should be implemented first or given greater emphasis during the system development process.

The responses to the question can serve as a means to validate and verify existing requirements or assumptions about the functionalities of an infield sensor connection system. By comparing stakeholders' opinions with existing requirements, developers can ensure that the system aligns with stakeholders' expectations and needs.

In summary, asking for opinions on the main functional requirements needed for an infield sensor connection system is a strategic approach to gather insights, validate existing requirements, prioritize functionalities.

Table 5: functional requirements needed for sensor connection system answers.

Questions	Answers	Requirement
1. Each measurement should be accompanied by a timestamp to enable the displaying system to indicate the time at which the measurement was recorded. <i>It underscores the necessity of associating a timestamp with every measurement captured by the system.</i>	6	F25
2. Each measurement must include coordinates, or the system will assign fixed coordinates to the measurement set by the user, allowing the displaying system to accurately depict the location where the measurement was taken. <i>It emphasizes the importance of associating geographical coordinates with each measurement recorded by the system.</i>	8	F26
3. Each measurement must include one or more sensor values, such as air temperature, wind speed, air humidity, and air pressure, to address the infield sensor use-case effectively. <i>It outlines the necessity for measurements to encompass various sensor values relevant to infield sensor applications.</i>	8	F26
4. The system shall support information about the sensor to enable the user to identify the sensor. Identification attributes are manufacture, model, type, serial number. <i>It underscores the importance of providing comprehensive sensor information to users for identification and management purposes.</i>	10	F28
5. The system can support a functionality which allows the user to access historical data. <i>It emphasizes the system's capability to provide users with access to historical data stored within the system.</i>	10	F29
6. The system must ensure that only the owner can give access to the sensor data. <i>It emphasizes the importance of data privacy and access control in the management of sensor data.</i>	10	F30
7. The system shall provide a unit of measure for each attribute which allows the user system to correctly display the information. <i>It emphasizes the necessity of associating appropriate units of</i>	8	F31

<i>measurement with each attribute to ensure accurate representation of data in the user interface.</i>		
8. The system shall provide a unit of measure for each attribute which allows the user system to correctly convert the measurement into a displaying format (e.g. C to F). <i>It underscores the system's capability to accommodate different units of measurement and facilitate seamless conversion between them to meet user preferences or requirements.</i>	9	F32
9. The system should furnish the measurement rate, unit, and bit resolution for every attribute, following the guidelines outlined in ISO 11783. <i>It emphasizes adherence to the standards specified by ISO 11783, which governs the data exchange protocols for agricultural equipment.</i>	8	F33
10. The system shall be able to limit the accessibility of a sensor to a certain time- frame. <i>It specifies the system's capability to restrict access to sensor data within predefined time intervals.</i>	8	F34
11. The system shall provide a functionality to search and add a sensor service to the used system of the user to receive sensor data. <i>It entails the system's capability to enable users to search for and integrate external sensor services into their existing system for data acquisition</i>	10	F35
12. The system should provide information about the supported capabilities. <i>It entails the system's ability to offer comprehensive documentation or guidance regarding its functionalities, features, and supported operations.</i>	8	F36
13. The system shall provide a means to uniquely identify a sensor to simplify the process of sensor identification for the end-user. <i>It emphasizes the necessity for the system to assign and manage unique identifiers for sensors</i>	10	F37
14. The system shall provide a location and type description for each sensor measurement. <i>It stipulates that the system should include information about the physical location and type of sensor associated with each measurement recorded</i>	10	F38

"In your opinion which are the main technical requirements needed for this system?"

The question "In your opinion, which are the main technical requirements needed for an infield sensor connection system?" serves to know opinions that allow us gathering insights directly from individuals who possess technical expertise or experience in the field of sensor connection systems. Their opinions can provide valuable input into identifying the key technical requirements necessary for the successful implementation and operation of Infield sensor connectivity system in the smart droplets solutions.

Overall, asking for opinions on the main technical requirements for an infield sensor connection system helps gather valuable insights from industry sector, inform technology decisions, identify technical challenges, and ensure that the system is designed and implemented to meet the needs and expectations of users effectively.

Table 6: Technical requirements needed for sensor connection system answers.

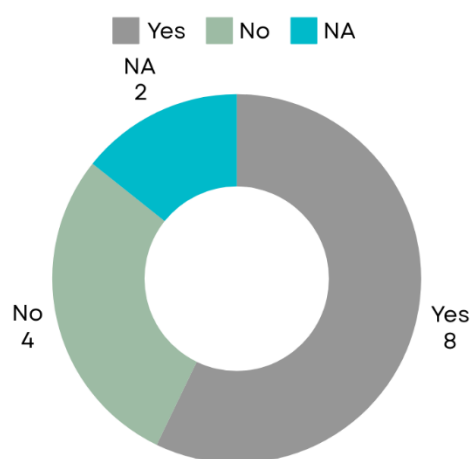
Questions	Answers	Requirement
1. The timestamp (sent along with any measurement) shall be formatted conform Coordinated Universal Time (UTC), ISO 8601 ⁴ . <i>The requirement states that the timestamp sent along with any measurement must adhere to the format specified by Coordinated Universal Time (UTC) according to ISO 8601 standards</i>	5	T23
2. The coordinates (sent along with the measurement) shall consist of a latitude, a longitude and an elevation value conforming to the reference coordinate system World Geodetic System (WGS84) (ISO 6709) ⁵ . <i>The requirement specifies the format for timestamps and coordinates accompanying measurements, ensuring consistency and compatibility with standardized representations</i>	5	T24
3. The system shall support a functionality to send measurements to a specific endpoint or a group of endpoints. <i>The requirement specifies that the system should have the capability to transmit measurements to designated endpoints or groups of endpoints</i>	4	T25
4. The system shall be able to uniquely identify endpoints. <i>The requirement specifies that the system must possess the capability to uniquely identify endpoints</i>	6	T26
5. The system shall support a functionality to check service specific capability of an endpoint. <i>The requirement specifies that the system should support a functionality to check the service-specific capabilities of an endpoint</i>	8	T27
6. The system shall use standard data formats to exchange the measurements. <i>The requirement specifies that the system should utilize standard data formats for exchanging measurements</i>	6	T28
7. The system shall ensure that measurements are exchanged only among granted endpoints. <i>The requirement specifies that the system must ensure that measurements are exchanged exclusively among authorized endpoints</i>	8	T29
8. The sending system must store the measurements for a limited duration in a buffer, allowing for temporary storage in case the recipient endpoint is momentarily unable to receive them. <i>The requirement stipulates that the sending system should have a mechanism to store measurements temporarily in a buffer for a limited duration.</i>	10	T30
9. The system shall support the listing of available endpoints to allow configuration for the equipment owner. <i>The requirement specifies that the system should provide functionality to list available endpoints, enabling configuration by the equipment owner</i>	8	T31
10. The measurements must come with information of the sending endpoint, to enable the receiving endpoint to identify the endpoint of the measurements. <i>The requirement specifies that measurements must include information about the sending endpoint to enable the receiving endpoint to identify the origin of the measurements.</i>	6	T32

⁴ ISO 8601 is an international standard for the representation of dates and times. It provides a standardized way to format dates, times, time intervals, and durations, enabling consistent communication and interpretation of temporal information across different systems, applications, and countries.

⁵ ISO 6709 is a standard that specifies representations of geographic coordinates, including latitude, longitude, altitude, and depth, in a concise and unambiguous manner. It defines a format for expressing these coordinates in a standardized way, allowing for consistent communication and interpretation of location information across different systems and applications.

11. The system can package one, some or all values in one message. No changing measurements during a period did not be updated in with a message. <i>The requirement specifies that the system has the capability to package one, some, or all values in a single message and that measurements that remain unchanged during a period do not need to be updated with a new message</i>	6	T33
12. The system shall provide capabilities to several meta information (accuracy of coordinates, type, frequency, unit, geographic coordinates/location, measurement technology, time of historical data). <i>The requirement specifies that the system must provide capabilities to handle several types of meta-information associated with measurements.</i>	6	T34

“Have your spraying machines a Field data management system?”



The result indicates that all 8 respondents answered affirmatively to the question "Have your spraying machines and Field data management system?" This means that all the spraying machines associated with these respondents are equipped with a software to collect data. The 4 of them answered that they did not incorporate this software. We must clarify that the most meant that they do not develop, but they can offer a system form an outsourced developer.

Figure 11: Field data management system.

“In your opinion which are the main functional requirements needed for this system?”

The question "In your opinion, which are the main functional requirements needed for a Field Data Management system?" is asked for soliciting opinions allows gathering insights directly from potential users of SMART DROPLETS technology.

Understanding the main functional requirements from the perspective of spraying manufacturers ensures that the Field Data Management system is designed to meet their needs effectively. By soliciting opinions SMART DROPLETS developers can prioritize features that are most important to users, leading to a more user-centric design. Comparing Industry' opinions with existing requirements or assumptions about the functionalities of a Field Data Management system helps validate and verify the accuracy and completeness of the requirements and it will help us to prioritize certain functionalities over others based on their importance, feasibility, or potential impact on improving field data management processes.

Table 7: functional requirements needed for field management system answers.

Questions	Answers	Requirement
1. The field data coming from machine or sensors shall be exchanged only among allowed agricultural software and service providers. <i>The requirement specifies that field data originating from machines or sensors should only be exchanged among permitted agricultural software and service providers.</i>	8	F39
2. Standard data formats shall be used to exchange the field data. <i>The requirement specifies that standard data formats must be utilized for exchanging field data.</i>	10	F40
3. The farmer shall be able to aggregate, and display data related to a specific field of his/her choice. <i>The requirement states that the farmer must have the capability to aggregate and display data pertaining to a specific field of their choice</i>	10	F41
4. The farmer shall be able to aggregate and display the field related data coming from different machines and sensors, in the agriculture software of his/her choice. <i>The requirement specifies that farmers should have the ability to aggregate and display field-related data originating from various machines and sensors within the agricultural software they prefer</i>	10	F42
5. The farmer shall be able to receive in the agricultural software of his/her choice, the field data coming from sensors and machines of different data platforms and manufacturers. <i>This requirement emphasizes the farmer's capability to receive field data from sensors and machines of various data platforms and manufacturers within the agricultural software they prefer.</i>	10	F43
6. The farmer shall be able to configure in the agricultural software of his/her choice, from which machine or sensors receive the field data. <i>This requirement underscores the farmer's ability to configure within their preferred agricultural software the sources from which field data is received, whether from machines or sensors.</i>	10	F444
7. The farmer/machine owner shall be able to select the time frame of field data measurements to be aggregated and displayed. <i>This requirement emphasizes the farmer's or machine owner's ability to select the time frame for aggregating and displaying field data measurements within their agricultural software.</i>	8	F45
8. The farmer/machine owner shall be able to see where the measurement in the field was taken. <i>This requirement specifies that the farmer or machine owner should be able to visualize the location where field measurements were taken within their agricultural software.</i>	9	F46
9. The machine owner shall be able to share the field data coming from machines with the agricultural software of the selected service providers. <i>This requirement emphasizes the machine owner's ability to share field data generated by machines with selected service providers through agricultural software.</i>	10	F47
10. The machine owner shall be able to select, in the agricultural software of his/her choice, the service providers to exchange the data with. <i>This requirement highlights the machine owner's capability to select, within their preferred agricultural software, the specific service providers with whom they wish to exchange data.</i>	12	F48
11. The service providers shall be able to integrate the field data from the machine owner with additional field information for documentation. <i>This requirement underscores the capability of service providers to integrate field data received from machine owners with additional field information for documentation purposes</i>	11	F49

12. The service providers shall be able to share with the machine owner the results of field data information integration. <i>This requirement underscores the capability of service providers to share with machine owners the results of integrating field data with additional information.</i>	10	F50
13. The user of the agricultural software must be able to clearly understand from which machine or sensor or service provider the field data are coming from. <i>This requirement emphasizes the importance of providing clear and transparent information to users of agricultural software regarding the sources of field data, including machines, sensors, or service providers.</i>	9	F51

“In your opinion which are the main technical requirements needed for this system?”

The question "In your opinion, which are the main technical requirements needed for a Field Data Management system?" is asked for gathering opinions allows for insights from individuals who possess technical expertise or experience in the field of data management systems. Their opinions can provide valuable input into identifying the key technical requirements necessary for the successful implementation of SMART DROPLETS solution.

Entrepreneurs may have encountered various technical constraints or challenges when dealing with data management systems in the past, and at the same time there might be multiple technical approaches and technologies available for implementing data management systems.

With this question we want to evaluate as well, the fact that implementing a Field Data Management system requires considering various technical infrastructure aspects, such as database management, data storage, data processing, and system integration, and technical requirements related to security and privacy are paramount for safeguarding sensitive data and ensuring compliance with regulations.

Table 8: Technical requirements needed for field management system answers.

Questions	Answers	Requirement
1. The system shall support a functionality to send aggregated field data to a specific endpoint (endpoint could be an agricultural software or a service provider). <i>This requirement highlights the system's capability to send aggregated field data to a specific endpoint, which could be either an agricultural software platform or a service provider</i>	8	T35
2. The system shall support a functionality to receive aggregated field data from a specific endpoint (endpoint could be an agricultural software or a service provider). <i>This requirement emphasizes the system's capability to receive aggregated field data from specific endpoints, which could be agricultural software platforms or service providers</i>	8	T36
3. The system shall support a functionality to receive field data from specific endpoints (endpoint could be a data platform). <i>This requirement highlights the system's capability to receive field data from specific endpoints, which could be data platforms or similar sources.</i>	6	T37
4. The system shall provide a means to identify in a unique way the endpoints. <i>This requirement highlights the necessity for the system to establish unique identification methods for endpoints, ensuring clarity and precision in data management and communication.</i>	5	T38
5. The system shall support a functionality to check the field data exchange capability of an endpoint. <i>This requirement underscores the importance of the system's ability to assess the field data exchange capability of endpoints.</i>	7	T39

6. The system needs to cope with the fact that field data can be sent to many endpoints. <i>This requirement emphasizes the system's ability to handle the distribution of field data to multiple endpoints simultaneously</i>	10	T40
7. The system shall use standard data formats to exchange the field data. <i>This requirement underscores the importance of adhering to standard data formats for the exchange of field data within the system.</i>	10	T41
8. The field data must come with the information about the receiving endpoint (the recipient of the transmission). <i>This requirement emphasizes the necessity for field data to include information about the receiving endpoint, ensuring transparency and accountability in data transmission</i>	8	T42
9. The system shall ensure that field data is exchanged only among granted endpoints. <i>This requirement highlights the importance of enforcing access controls to ensure that field data is exchanged only among authorized endpoints within the system.</i>	6	T43
10. The field data must come with the information about the sending endpoint (the source of the transmission), to let the receiver to identify the endpoint the field data are coming from. <i>This requirement emphasizes the importance of including information about the sending endpoint in field data transmissions</i>	8	T45
11. The field data must come with the authentication information of the sending endpoint, in order to let the receiver to verify if the sending endpoint is allowed to send data to it. <i>This requirement underscores the necessity for field data to include authentication information of the sending endpoint.</i>	10	T46
12. The receiving endpoint shall verify if it is the correct recipient of the field data, to accept or refuse it. <i>This requirement mandates that the receiving endpoint must verify if it is the intended recipient of the field data, allowing it to either accept or refuse the data transmission.</i>	10	T47
13. The system shall support a functionality to let the machine owner to select the endpoints the field data will be shared with. <i>This requirement underscores the importance of allowing the machine owner to have control over which endpoints receive the field data generated by their machines.</i>	6	T48
14. The system shall support a functionality to configure the list of available endpoints. This functionality must include mechanisms of account pairing and granting access to the specific endpoints. <i>This requirement emphasizes the necessity for the system to provide a functionality that enables the configuration of available endpoints, including mechanisms for account pairing and granting access to specific endpoints</i>	8	T49
15. The system shall support a functionality to inform the sending endpoint about the results of data transmission over the network. <i>This requirement highlights the need for the system to provide a functionality that informs the sending endpoint about the results of data transmission over the network.</i>	10	T50

4 Discussion

Despite the low participation in this survey, the information provided provides essential insights that could be interpreted regarding the aims of SMART DROPLETS and some insights into the hitherto existing situation in the spraying machine sector from the area of Ag-technology. Most of the participating companies were from Spain, and Mediterranean countries, who provided valuable information about the concerns and digitalization level of Industry. These companies face opportunities and obstacles in the field of digital agriculture, but one thing is clear, and that is that the market is increasingly interested in digital solutions incorporated into phytosanitary application machines.

The participants cover almost, all company sizes, from small, medium-sized to global players. It became clear that the larger a company, the more diverse markets have an impact on the development of its technologies. Furthermore, the same companies also see greater potential in the same markets as they are active in several of them. For example, in Mediterranean countries where there is intensive agriculture with great added value, the companies interviewed have a high participation in these markets.

Based on the information provided through the questions regarding ISOBUS and its functional characteristics, it could be determined that the manufacturers are already considering interoperability for manufacturer-independent control and communication through standardization. The Section Control task controller is a symbol of this as an interoperability feature. This standardized data protocol enables a manufacturer-independent control between tractors and attachments of various types of implements such as sprayers. In this area of standardization, most participants (mostly FEMAC members) use ISOBUS as functional feature.

We realize as well, that in terms of developing new digital solutions, it could be determined that the companies are increasingly operating in-house solutions. Furthermore, the companies increasingly indicated their connectivity as a cloud-based solution.

Another characteristic that we have been able to see from the interviews carried out is that the majority seem to be clear that there is no turning back, that although in some of the markets in which they operate, they still have a certain degree of maturity left, we see those first-class markets level, they see it as another value of the machines, especially when we refer to specialty crops, like apple and fruit stone.

Furthermore, the survey showed that the industry is increasingly focused on offering solutions that provide added value to farmers, its customers. They are aware that the machines should in the future be able to decide for themselves the amount of phytosanitary to apply based on real needs, and in a totally autonomous way.

One topic that emerged from a follow-up conversation with some manufacturers was the lack of interoperability between the different systems on the market. One company named one problem as major: Farmers do not want to work with different systems. At the same time, they must use different systems due to business specific systems and the lack of interoperability between those.

In regard of the most important topic DIS System, answers said that this technology is not fully implemented among the industry, an effort could be done to promote the technology adoption in developing countries by considering possibility of simplifying this DIS e technology and proposing cost effective DIS designs to be affordable and adoptable in the context of small-scale farming. Direct injection spraying (DIS) represents a dynamic approach to applying chemicals, adjusting their concentration in real-time in

accordance with ground speed. This advancement in variable rate technology has emerged alongside the evolution of precision agriculture (PA), aiming to deliver tailored agricultural inputs. Notably, the integration of electronic and process control devices in spraying machineries will be pivotal, facilitating the cost-effective integration of controllers, sensors, and actuators into spraying equipment.

5 Conclusions

In conclusion, despite the relatively low participation in the survey, the insights gleaned provide valuable perspectives on the objectives of SMART DROPLETS and shed light on the current landscape within the agricultural technology sector, particularly in spraying machinery. Predominantly sourced from companies in Spain and Mediterranean countries, the data offers crucial insights into the digitalization levels and concerns within the industry. Companies, regardless of size, are increasingly recognizing the importance of digital solutions in agriculture, with a growing interest in incorporating such technologies into phytosanitary application machines.

The survey reveals that larger companies, with their diverse market presence, are more deeply impacted by market dynamics, while simultaneously recognizing greater potential in those markets where they are active. Notably, interoperability through standardization, particularly evident in ISOBUS functionality, is being embraced as a means to facilitate manufacturer-independent control and communication, exemplified by features like Section Control task controllers.

Moreover, there is a clear trend towards in-house development of digital solutions, alongside a growing emphasis on cloud-based connectivity. Participants unanimously express the irreversible shift towards digitalization, viewing it to provide added value to farmers. The future of agricultural machinery, as envisioned by respondents, involves autonomous decision-making capabilities, particularly in determining optimal phytosanitary application levels based on real-time needs.

However, challenges such as interoperability issues persist, hindering seamless integration of various systems in the market, a concern echoed by both manufacturers and farmers. Regarding Direct Injection Spraying (DIS) technology, while its potential is recognized, its full implementation remains limited, suggesting the need for efforts to promote its adoption, particularly in developing countries, through simplified and cost-effective designs suitable for small-scale farming contexts.

In summary, the future trajectory of spraying technology lies in the continued integration of electronic and process control devices, alongside a concerted effort towards standardization and promotion of innovative solutions that align with the evolving needs of farmers and the agricultural sector as a whole.



6 Result [End users]

6.1 Method and Procedure

Following the preparation of the questionnaire, the corresponding electronic survey was made available through the google forms platform, where it was included tools for data privacy disclosures and opt-in statements in surveys. The survey link⁶ was disseminated to all SMART DROPLETS partners, who then translated in their own local language, and were asked to further disseminate it to an as-wide-as-possible audience. The survey remained online for a total of 30 days. After that, responses were filtered to eliminate invalid ones, before proceeding with their analysis.

6.2 Participants

In total, up to 20 responses were collected from farmers from different countries, and different types of crops. Below we detail the number of responses by country.

N.	COUNTRY	ANSWERS
1	SPAIN	6
2	GREECE	6
3	SERBIA	3
4	LITHUANIA	5

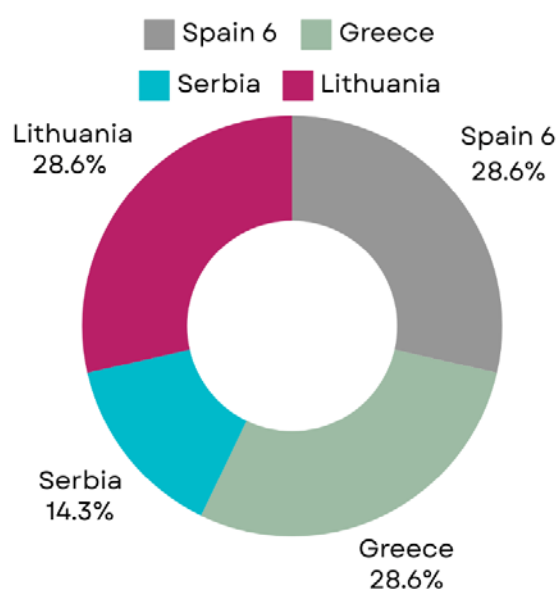


Figure 12: Farmers country of origin.

⁶ https://docs.google.com/forms/d/e/1FAIpQLSdxtSB3bvZdpaCUsysxt-Smd1M1EEgO9bfgqmSMBCZNoNEVA/viewform?usp=sf_link

6.3 Farmers' profile

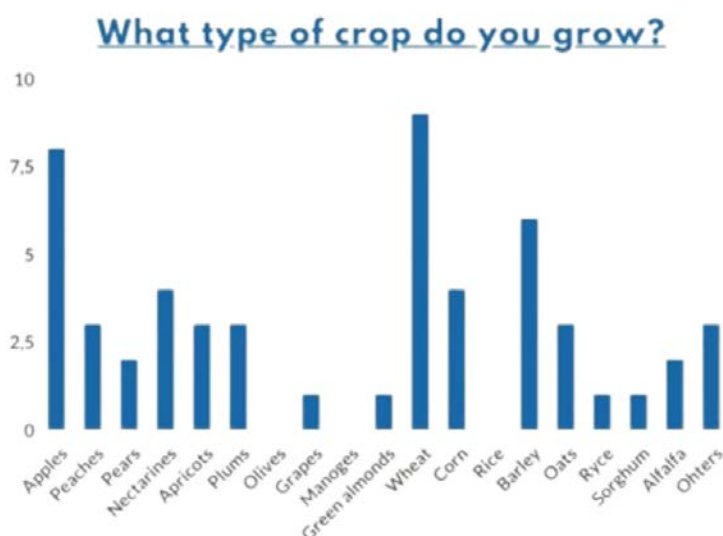


Figure 13: Type of crops

As per the project methodology and objectives, the system will be deployed in two diversified and complementary environments to evaluate and test its components as thoroughly as possible. Two demonstrators are envisaged, one in an **apple orchard**, and another in open **wheat fields**. The apple demonstrator will take place in a commercial orchard **in Spain**, and the second in a commercial wheat farm **in Lithuania**. Crop selection was not based on crop availability, nor was it random. **Apples are among the crops where the highest amounts of pesticides are used** (up to 8 months per year²¹). The focus will be on apple scab and alternaria fungal diseases because insufficient control measures can lead to economic losses of 70% of the production value due to apple scab²² and 50% apple defoliation can occur from uncontrolled alternaria infestations²³. Foliar fertilization with Nitrogen is critical for overall yield, with a notable amount of 80-150 kg/ha applied in each treatment.

Wheat accounts for 44%²⁵ of the main cereal production in the EU-27. The focus will be on chemical weeding, nitrogen fertilization and fungicide applications. Weeds can reduce wheat yield by 15%–20% per annum²⁶, while Nitrogen application are estimated to 45 kg/ha in high productivity farms²⁷. The targeted enemies and demonstration scenarios will be further refined in the context of user's requirements activities. The choices were based on the amounts of fertilizers and pesticides used and whether the pesticides used to fight the selected problems belong to the more hazardous pesticides identified within the Green Deal.

Among the different answers obtained, most fruit growers grow apples, although the two main cooperative societies in Catalonia have a wide variety of stone crops, such as apricots, nectarines and apricots.

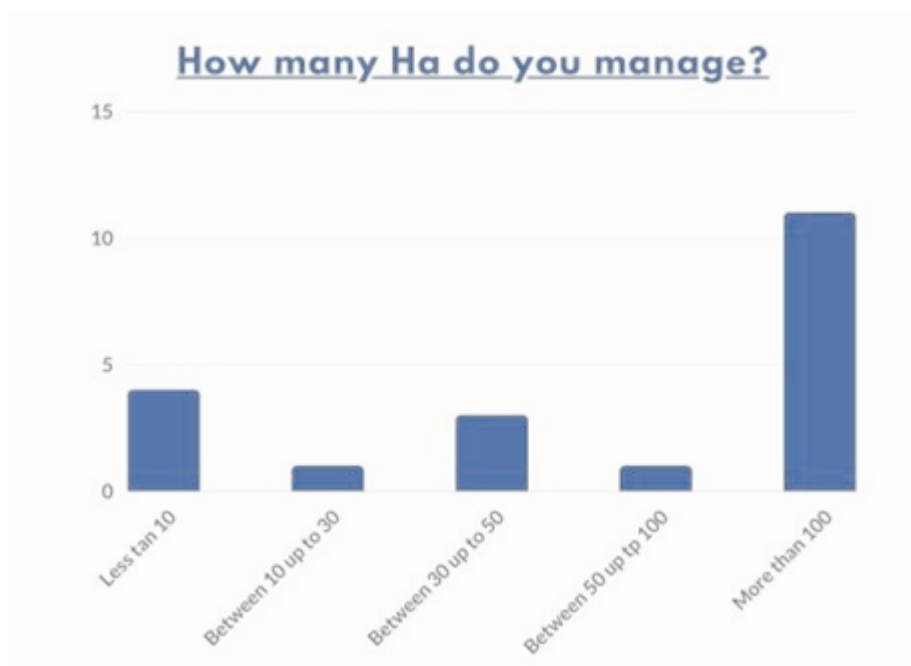


Figure 14: Number of Ha managed.

In order to have an idea of the size of the agricultural holdings and their size, we asked the respondents how many hectares they cultivated. The result tells us that more than half have holdings larger than 100 Ha. Secondly, 4 farmers say they have holdings of less than 10 Ha. In third place is the group of farmers with holdings of between 30 and 50 Ha.

It should be noted that among the Catalan stone fruit producers, these are large, highly professionalized holdings with large areas of crops.

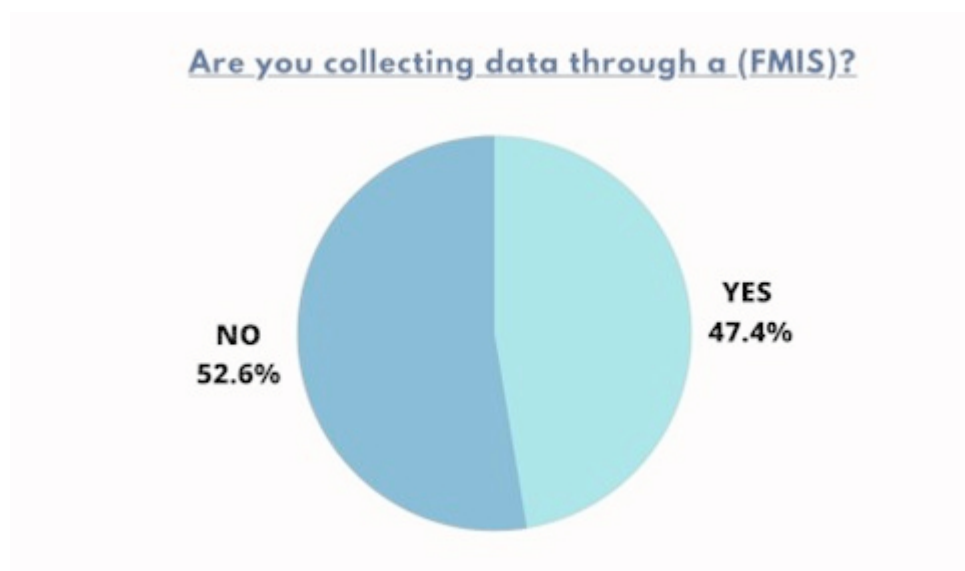


Figure 15: Use of Farm Management Information Software - FMIS

Another aspect we wanted to ask the respondents was the type of software they used, if that was the case, and which manufacturer-brand it was. It should be considered that they will regularly be asked to turn over a series of data (see table 3), and therefore the form that must be turned over and treated will be determined to ensure the correct processing of the data.

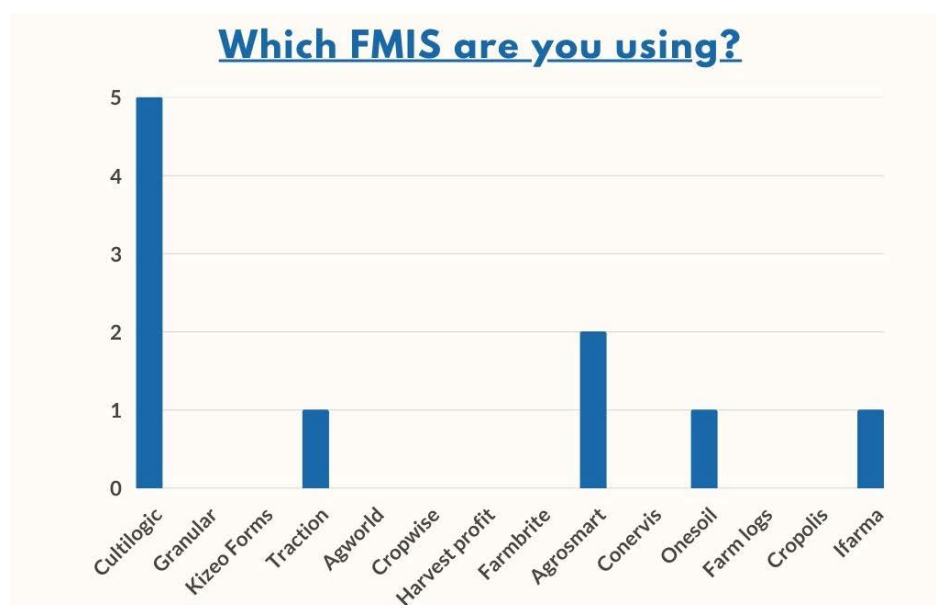


Figure 16: Brand name of FMIS

As we can see among those who answered YES, the majority used the CULTILOGIC digital field notebook, developed by a Catalan firm E COSTAS, SL, which is a member of the FEMAC cluster.

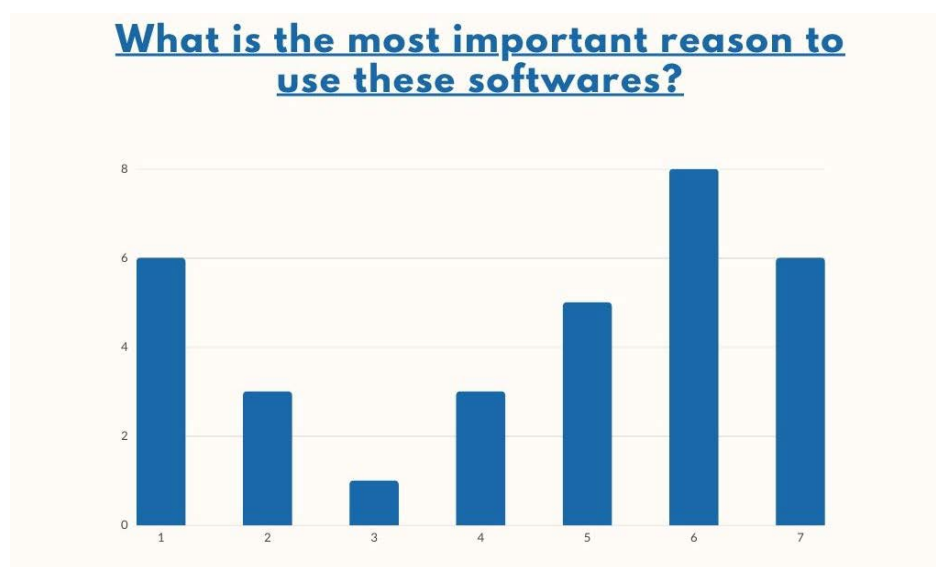


Figure 17: Reason to use FMIS

1. Reduce and optimize pesticide use.
2. Reduce and optimize fertilizer use.
3. Reduce and optimize water consumption.
4. Increase the crop yield and the net profit of the farm.
5. Manage and control the costs of the production.
6. Optimizes farm production activities and operations.
7. Comply with Regulation (EU) 2016/2031 on protective measures against pests of plants.

We wanted to ask the farmers what the main reason would be why they used this type of software, and most agreed on the need to optimize agricultural activities and processes, first and the obligation to comply with the regulation EU 2016/2031 on protective measures against pests of plants.

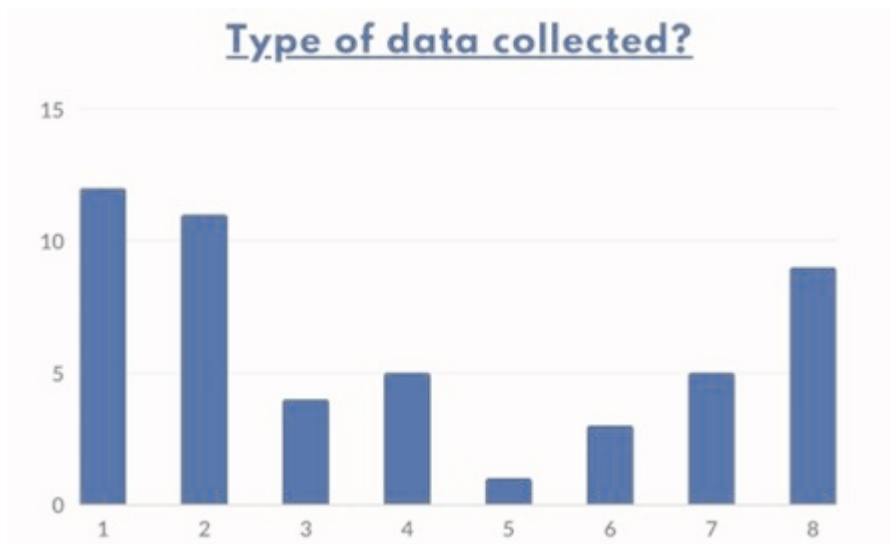


Figure 18: Type of data collected

1. Fertilization events
2. Pesticide application events
3. Irrigation management (e.g., date, amount)
4. Damaging events (e.g., pest breakouts, hailstorm, crop disease)
5. Biophysical properties (e.g., yield biomass)
6. Weather
7. Development stages (e.g., sowing date, flowering)
8. Harvest (e.g., date, amount)

Considering the type of data, they collect through this software; the fertilizations events and pesticides application events are the two majors' variables collected.

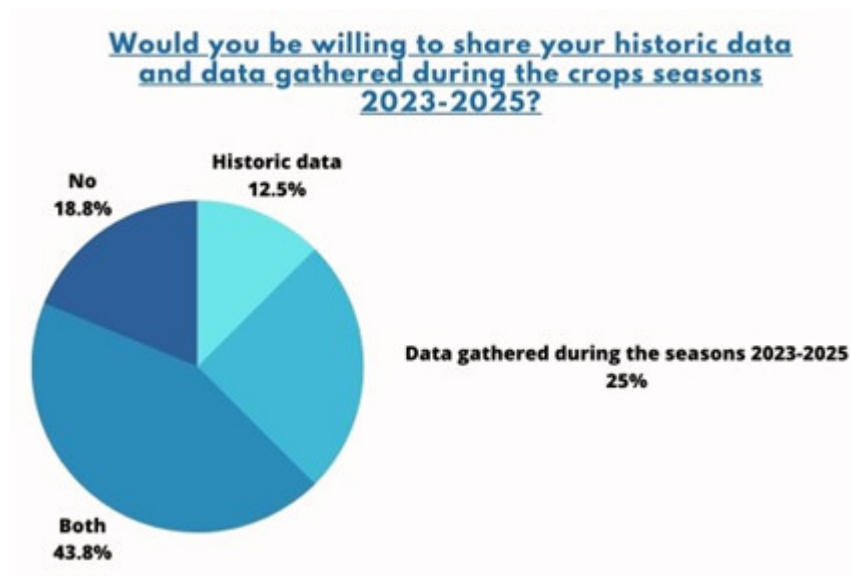


Figure 19: Willingness to participate in the Project

In the end, we wanted to know how many of the interviewees would be willing to collaborate on the project and what kind of data they would be willing to share. 43% have decided to share both historical data and data obtained during the 2023 to 2025 campaigns.

6.4 End users' requirements

Once we obtained the commitment of a group of farmers willing to participate in the Project, we wanted to know what, in their opinion, were the technical and functional requirements that an advanced crop application and protection system should have.

With this purpose we focused on the consolidated requirements and answered in their opinion which ones an intelligent atomizer should incorporate.

Of the 20 farmers who responded to the first survey, we were able to interview 20 of them by telephone. The purpose was to know, once the requirements were defined by the manufacturers, which ones were necessary for them. We did not want to know to what degree they were more important, but only if they believed it was necessary to incorporate them into their daily use machines.

This was the result.

“In your opinion which are the main functional & technical requirements needed for a smart spraying machine?”

Table 9: End users' requirements

No.	Requirement	Answers
C1	Precision Spraying Capability: The machine should have the ability to precisely target specific areas or crops, minimizing pesticide usage and reducing environmental impact.	10
C2	Real-Time Monitoring and Analysis: Integration with data platforms for monitoring and analyzing field conditions, weather patterns, and crop health in real-time, allowing for informed decision-making	6
C3	Compatibility with Agricultural Software Systems: Seamless integration with existing agricultural software solutions for task management, data analysis, and	10
C4	Connectivity with In-Field Sensors: Ability to connect with in-field sensors to collect data on soil moisture, crop health, pest infestations, and other relevant parameters.	10
C5	Adherence to Environmental and Safety Standards: Compliance with regulations and standards for pesticide application, ensuring safe and environmentally	5
C6	Efficiency in Pesticide Usage: Optimization of pesticide usage through advanced algorithms and techniques to minimize waste and reduce costs.	10
C7	Autonomous Operation or Remote Control: Capability for autonomous operation or remote control, allowing farmers to manage spraying tasks efficiently and	5
C8	Adaptability to Different Field Conditions and Crop Types: Versatility to adapt to various field conditions, terrains, and crop types, ensuring optimal performance	8
C9	Precision Delivery: The DIS system must be capable of delivering precise amounts of pesticides directly to the target area with high accuracy and	6
C10	Integrated Control System: It requires a sophisticated control system that can accurately regulate the flow rate and timing of pesticide injection based on factors such as field conditions, crop type, and pest pressure.	7
C11	Compatibility with Various Chemicals: The system should be compatible with a wide range of pesticides, herbicides, fungicides, and other agrochemicals commonly used in agriculture.	8
C12	Minimization of Environmental Impact: DIS systems should minimize environmental impact by reducing pesticide drift, runoff, and overall usage, thus promoting sustainable agricultural practices.	8
C13	Safety Features: Safety features such as automatic shut-off valves, pressure sensors, and leak detection mechanisms are essential to prevent spills, leaks, or	10
C14	Ease of Integration: DIS systems should be easily integrated with existing agricultural machinery, such as sprayers or irrigation systems, to facilitate	5
C15	Data Monitoring and Reporting: Integration with data monitoring and reporting systems allows farmers to track pesticide usage, monitor application rates, and analyze application effectiveness for better decision-making and regulatory	10
C16	Reliability and Durability: The system must be reliable and durable enough to withstand the rigors of agricultural operations, including harsh weather conditions, frequent use, and exposure to chemicals.	10

C17	User-Friendly Interface: An intuitive and user-friendly interface is essential for operators to set up, monitor, and adjust the DIS system parameters easily.	10
C18	Autonomous Navigation: The machine should be capable of autonomous navigation in the field, including obstacle detection and avoidance	4
C19	Precision Spraying: It must have precise spraying capabilities to apply pesticides or other substances accurately to targeted areas, minimizing waste and environmental impact	10
C20	Sensor Integration: Integration with various sensors such as GPS, LIDAR, cameras, and environmental sensors to gather real-time data for decision-making	10
C21	Data Processing: Onboard data processing capabilities to analyze sensor data and make informed decisions regarding spraying patterns, dosage, and areas to treat	10
C22	Communication Systems: Integration with communication systems to receive commands, transmit data, and communicate with other farm equipment or control centers	9
C23	Safety Features: Implementation of safety features such as emergency stop buttons, collision avoidance systems, and fail-safe mechanisms to prevent accidents	10
C24	Weather Monitoring: Integration with weather monitoring systems to adjust spraying operations based on current weather conditions and forecasts	8
C25	Remote Monitoring and Control: Capability for remote monitoring and control, allowing operators to oversee operations and intervene if necessary.	7
C26	Environmental Awareness: Consideration of environmental factors such as wind direction, soil moisture, and crop conditions to optimize spraying effectiveness and minimize environmental impact.	7
C27	Regulatory Compliance: Adherence to regulatory requirements and standards related to pesticide application, safety, and environmental protection	6

6.5 End users' requirements conclusions

The conclusions drawn from end-user farmers regarding the technical and functional requirements for spraying machines reflect their practical insights and preferences based on real-world experiences. These conclusions can offer valuable guidance for future developments based on SMART DROPLETS technologies.

It is well known that farmers prioritize machines that offer precise application capabilities, allowing them to target specific areas or crops with accuracy, and it suggest that machines with superior precision result in more effective pest and weed control while minimizing wastage of inputs. At the same time, end users emphasize the importance of machines that are user-friendly and accessible, even for operators with varying levels of technical expertise, with intuitive interfaces, clear instructions, and ergonomic designs that facilitate efficient operation in diverse farming environments.



Farmers value machines that offer flexibility and customization options to suit different crop types, field conditions, and pest pressures. Conclusions suggest that adaptable spraying technologies, such as variable rate application systems, are highly favored for optimizing input usage and addressing varying agricultural needs.

Farmers start expressing a strong preference for machines that prioritize safety for both operators and the environment. They seek for machines that integrate safety mechanisms, and adherence to environmental regulations to minimize risks associated with pesticide application.

They recognize the value of integrating spraying machines with digital technologies for enhanced efficiency and precision, like GPS-guided navigation, automated application mapping, and remote monitoring capabilities are increasingly sought after for optimizing spraying operations and data management.

But finally and not less important, while farmers prioritize advanced features and functionalities, affordability and return on investment remain critical considerations. Farmers value machines that offer a balance between performance, cost-effectiveness, and long-term benefits, ensuring that investments in spraying equipment yield tangible returns in terms of crop yield, quality, and profitability.

7 Next actions

In the deliverable D2.6 Industry needs and requirements analysis, we analyzed key sources to gain requirements with respect to the development and operation of a Data Platform with proper Agri-data models, targeting the industry and farmers, following a comprehensive methodology. This deliverable constitutes the first version of the report containing the detailed analysis of the requirements of the industry and the use cases definition, that will be deployed in two diversified and complementary environments to evaluate and test its components as thoroughly as possible (one in an apple orchard, and another in open wheat fields).

To this end, an extensive list of industry Requirements' specifications was produced indicating both the source requirement and information about the views, needs, and concerns of different type of machinery manufacturers, who have showed an interest in the project.

This set of the information along with the functional requirements will be used for the evaluation of the implementation to improve the SMART DROPLETS platform, that will also define measurable and well-defined metrics to address economic, agronomic, technical, and environmental needs. Economic/ agronomic issues are dependent on each crop and on each operation, such as yield production, quality assessment, number of field operations, reduction of spraying drift, accuracy of spraying application. Technical and metrics obtained, will be related to the key technologies developed and integrated in WPs 3-5, such as the autonomy of the system, the performance of selective chemical application, the modelling and prediction capacity of AI systems. The environmental metrics are linked with agronomic aspects and will encapsulate the impact of the proposed solution at reducing chemicals, natural resources usage and other Green Deal key-objectives. These will be measured in WP5.



Regarding the farmer questionnaire, it should be noted that due to the type of end users and the limited time since the start of the project, few participants provided feedback to the questionnaire. However, the questionnaire responses together with the interviews provided a solid basis for the identification of farmers' requirements. In addition, we were able to obtain the commitment of at least 15 farmers who are willing to collaborate in the project and provide their data.

It is worth mentioning that in the definition of the process of the definition of the methodology, the content of the interviews, the requirements to be analyzed, as well as the content of the electronic questionnaire, all the main partners of the consortium participated. The involvement of the industrial partner AGROMAR, as well as the University in charge of developing the model, was significant because it resulted in a more coherent definition of requirements, which also encapsulated the vision of the industrial sector. In summary, this deliverable provides a sufficient basis for the technical developments of the system proposed in SMART DROPLETS, which will take place throughout the Project.

Task 2.6 will continuously collaborate with:

- All **WP2** tasks to establish the framework for a structured and sustained dialogue with a range of stakeholders, incl. user industries, in both technical and training aspects of the project.
- **WP3** to implementation of the Smart Droplets data management platform.
- **WP4** which will design and develop the software architecture for autonomous navigation and intelligent spraying capabilities.
- **WP5** to plan and execute all demonstrators to evaluate, monitor, demonstrate and collect feedback for each of the proposed solutions.
- And filled the **WP 6** to provide information set up a clear and strategic Dissemination, Exploitation and Communication

This work will be thoroughly analyzed in the deliverable D2.1 entitled “Industry needs & requirements analysis” which is due on M9.



8 Annexes

Annex 1 End user farmers: Questionnaires in different languages

 SRB	https://forms.gle/SPC1SfrTi3AKUsxx5
 FR	https://forms.gle/PtS51JD2A1wfFGEo8
 CAT	https://forms.gle/ph5urMwZA9JFr2Ne7
 ENG	https://forms.gle/b9NFCjNcfMjVx7gR9
 NL	https://forms.gle/4HBKdu2LvrovYKDdA
 LT	https://forms.gle/7u9B9DVu98H7Z4ac8
 GR	https://forms.gle/7u9B9DVu98H7Z4ac19

Annex 2 Industry segment: Questionnaires in 2 languages

 ES	https://forms.gle/GHbpQ9QwDEgWLRPK8
 ENG	https://forms.gle/KB3FaKkdr1jmKMAV8