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Smart Droplets

D2.1 Industry Needs & Requirements Analysis

smartdroplets.eu

Author(s)/Organisation(s)	**Enrique Pedrós/FEMAC**
Contributor(s)	**Thomas /Agrifood LT**
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SMART DROPLETS CONSORTIUM			
PARTICIPANT NUMBER	**PARTICIPANT ORGANISATION NAME**	**SHORT NAME**	**COUNTRY**
1	**GEOPONIKO PANEPISTIMION ATHINON**	**AUA**	**GR**
2	**WAGENINGEN UNIVERSITY**	**WU**	**NL**
3	**FUNDACIO EURECAT**	**EUT**	**ES**
4	**FONDACIJA VIZLORE LABS**	**VLF**	**SRB**
5	**FOODSCALE HUB GREECE ASSOCIATION FOR ENTREPREUNERSHIP AND INNOVATION ASTIKI MI KERDOSKOPIKI ETAIREIA**	**FSH**	**GR**
6	**AGREENCULTURE**	**AGC**	**FR**
7	**AGRIFOOD LITHUANIA DIH**	**AFL**	**LT**
8	**PETKOS ANONYMI ETAIREIA**	**AGROMA SA**	**GR**
9	**CLUSTER DE LA MAQUINARIA I DELS MEDIS DE PRODUCCIO AGRICOLA DE CATALUNYA**	**FEMAC**	**ES**

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Glossary Terms

TERM	DEFINITIION
Agricultural Field Notebook	An Agricultural Field Notebook is a specialized notebook or journal used by agricultural professionals, researchers, agronomists, and farmers to record observations, data, and other pertinent information related to agricultural activities and fieldwork
Agricultural Software	This can be an on-premises application, cloud solution or software running on a single device like a PC, tablet, or smartphone. Agricultural software can receive or send data to provide extra services (documentation, evaluation, planning, analytics, etc.). Agricultural software can be connected to other systems or devices via internet or directly. FMIS (Farm Management Information Systems) is an example of agricultural software.
Artificial Intelligence	Artificial Intelligence (AI) refers to the simulation of human intelligence processes by machines, especially computer systems. These processes include learning (the acquisition of information and rules for using the information), reasoning (using rules to reach approximate or definite conclusions), and self-correction.
AI models	AI models are computational structures or algorithms that simulate aspects of human intelligence to perform specific tasks or solve problems. These models are designed to process large amounts of data, learn from patterns within the data, and make predictions or decisions based on their learned knowledge.
Autonomous Navigation System	An Autonomous Navigation System is a technology that enables vehicles or robots to navigate and move in their environment without direct human control or intervention. These systems utilize various sensors, algorithms, and decision-making mechanisms to perceive the surroundings, plan optimal paths, and execute maneuvers safely and efficiently
Autonomous Retrofitted tractor	Retrofitting existing vehicles with autonomous technology has the potential to revolutionize agriculture by increasing efficiency and reducing labor costs. By equipping tractors with sensors, GPS systems, and other autonomous features, they can perform tasks such as plowing, planting, and harvesting without the need for constant human supervision.
Canopy characterization	Canopy characterization refers to the process of analyzing and describing the structure, composition, and dynamics of plant canopies. The canopy of a plant refers to the uppermost layer of foliage, branches, and stems that forms the overhead covering of a forest, crop, or other vegetation. Canopy characterization involves various techniques and methods to quantify and understand the physical, physiological, and ecological attributes of plant canopies.
Capabilities	The purpose of capabilities is the negotiation whether a specific resource is capable of fulfilling a specific role in a specified use case or scenario. Capabilities are a list of technical message types, services or commands which a communication unit, an agricultural software or a data platform supports.

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Data connectors	Data connectors are software components or tools that facilitate the integration and interoperability of data between different systems, applications, or databases. They act as bridges or adapters, enabling seamless communication and data exchange between disparate technologies. Data connectors play a crucial role in modern IT architectures by simplifying data integration, automating workflows, and improving data accessibility
Data confidentiality	The data confidentiality refers to the data protection against unauthorized access.
Data stream management	Data stream management is the process of ingesting, processing, analyzing, and managing continuous streams of data in real-time or near real-time. Unlike traditional batch processing, which operates on static datasets, data stream management systems (DSMS) handle data that is constantly flowing and evolving.
Data warehouse	A data warehouse is a centralized repository that stores structured and organized data from various sources within an organization. It serves as a comprehensive and integrated storage solution for large volumes of data, enabling efficient retrieval, analysis, and reporting for decision-making purposes
Data exchange protocols	Data exchange protocols are standardized sets of rules and conventions that govern the format, structure, and transmission of data between different systems or devices. These protocols ensure that data can be efficiently and accurately exchanged, regardless of the specific hardware or software platforms involved.
Data infrastructures	Data infrastructures refer to the foundational framework and architecture designed to support the collection, storage, management, processing, and analysis of data within an organization or system
Data integrity	The data integrity refers to the validity and accuracy of the data. It involves security mechanism to protected data against unauthorized alterations, both in data storage and in data transfer.
Data Management Platform	A Data Management Platform (DMP) is a technology platform that aggregates, organizes, and analyzes large volumes of data from multiple sources to create unified customer profiles and enable targeted advertising, marketing, and audience segmentation.
Data Owner	The Data Owner is the legal owner of any information flowing through the network. An information can also be person related.
Data Provider	The Data Provider is a participant in the SMART DROPLETS Network which is mainly providing information into the network for further use.

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Digital Platform	A digital platform is a software-based framework or infrastructure that facilitates interactions, transactions, and collaborations between different users, businesses, and entities in a digital environment. It serves as a centralized hub or ecosystem where users can access, share, and exchange resources, services, and information seamlessly.
Digital twins	A digital twin is a virtual representation or digital counterpart of a physical object, system, process, or environment. It is created using data collected from sensors, IoT devices, and other sources, and is designed to mimic the behavior, characteristics, and interactions of its real-world counterpart in a virtual environment
Direct Injection Spraying (DIS)	Direct Injection Spraying (DIS) is an innovative technology used in agriculture for the precise application of pesticides, fertilizers, or other agricultural chemicals directly into the irrigation water stream. Unlike traditional spraying methods where chemicals are mixed with water in a tank and then sprayed onto crops, DIS injects the chemicals directly into the irrigation system at the point of application.
Farm Management Information Software	Farm Management Information Software (FMIS) refers to specialized computer programs or systems designed to assist farmers and agricultural professionals in managing various aspects of farm operations efficiently. FMIS provides tools and functionalities to collect, organize, analyze, and utilize data related to crop production, livestock management, financial tracking, inventory management, and more
Farmer	A farmer is an individual or entity involved in agricultural production, typically owning, or managing land for the purpose of cultivating crops, raising livestock, or both. Farmers play a crucial role in food production, supplying crops, livestock products, and other agricultural commodities to meet the needs of consumers and various industries.
ISOBUS DDI	A DDI (literally: Data Dictionary Identifier) represents a device or process parameter in the ISOBUS norm. Over 600 DDIs are defined in ISO 11783-11, see http://dictionary.isobus.net/isobus/. DDIs are used, for example, in device descriptions to describe properties, the supported settings, and the provided data of a machine. DDIs are also used to identify the data records in telemetry messages.
Machine Vision	Machine vision, also known as computer vision, is a field of artificial intelligence and image processing that enables machines, typically computers or robots, to interpret and understand visual information from the real world. It involves the use of cameras, sensors, and algorithms to capture, process, analyze, and interpret images or video data to perform tasks that require human-like vision capabilities.
Pesticide	Pesticides are substances or mixtures of substances intended for preventing, destroying, repelling, or mitigating any pest. This includes insects, rodents, weeds, fungi, bacteria, viruses, and other organisms that can harm crops, animals, humans, or structures. Pesticides are widely used in agriculture, public health, forestry, and residential settings to protect crops, control vector-borne diseases, manage invasive species, and maintain public hygiene.

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Resource	A resource is any piece of hardware, software or information which serves in the Project. A resource needs tobe uniquely identifiable and must be able to propagate its capabilities (see Capabilities), either by itself or through the provider of the resource.
Scenario	A scenario is a structured sequence of actions and occurrences designed to serve a particular purpose. It represents a standardized set of steps that fulfill a specific function. Scenarios are commonly employed across various use cases, serving as shared processes that offer advantageous functionality or act as precursors to other operations. For instance, consider the scenario preceding the communication between two participant systems, known as System Pairing, where a defined process facilitates their interaction.
Security and data protection	Security and data protection encompass a range of measures and practices designed to safeguard sensitive information, prevent unauthorized access, and mitigate risks associated with data breaches or misuse
Sensor	This is a device which detects or measures a physical property and records, indicates, or otherwise responds to it. The specific input could be light, heat, motion, moisture, pressure, or any one of a great number of other environmental phenomena. The output is generally a signal that is converted for further processing.
SLAM System	SLAM stands for Simultaneous Localization and Mapping. It's a technique used in robotics and autonomous systems to create maps of an unknown environment while simultaneously determining the robot's position within that environment.
SMARTDROPLETS data services	SMART DROPLETS data services It's a system designed to grant access to specific functions or features, utilizing a defined interface, and ensuring that this access adheres to specified rules and regulations outlined in the service description."
SMART DROPLETS consortium	SMART DROPLETS consortium is a companionship that combines SMART DROPLETS stakeholders coming from the agriculture space (machinery manufacturers, agronomists, research institutes, industry- /IT-representatives, ...) in this project. The list of the stakeholders can be found in the Grant Agreement. SMART DROPLETS consortium is responsible to deal with governance and exploitation topics for and across the SMART DROPLETS stakeholders.
Spraying Machine	An agricultural spraying machine, often referred to as a sprayer, is a piece of equipment used in farming to apply pesticides, herbicides, fertilizers, or other chemicals onto crops. These machines are designed to distribute the desired substance efficiently and evenly over a large area of land.

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Abbreviations and Acronyms

List of Abbreviations and Acronyms	
AFN	Agricultural Field Notebook
AI	Artificial Intelligence
CAP	Common Agricultural Policy
FMIS	Farm Management Information Software
FR	Functional Requirements
KO	Key Objectives
KPIs	Key Performance Indicators
SLAM	Simultaneous Localization and Mapping
UC	Use Case
UCD	User Centered Design

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1 Introduction

The purpose of this deliverable, as the technical output of the project, is to elicit the business and user requirements specifications for the SMART DROPLETS system to be deployed on the two demonstrator cases. The deliverable describes the steps and actions performed in” Task 2.1 User requirements and measurable metrics” during the first 6 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 will cover the data infrastructure, the robotic platform and the implement (sprayer). The compatibility and interaction between sprayer and robotic platform will be defined to provide a set of both technical and functional requirements for the technical work in WP3 & WP4 and serve as the prerequisites for pilot planning in WP5. This task will also define measurable and well-defined metrics to address economic, agronomic, technical, and environmental needs.

The involvement of machine manufacturers in providing technical requirements plays a pivotal role in standardizing agricultural machine interoperability. Cluster FEMAC, in collaboration with partners Agrifood Lithuania DIH, Fundación EURECAT; Geoponiko Panepistimion ATHINONics, has formulated a pertinent questionnaire for this purpose. Emphasizing the imperative of seamless system connectivity, a core objective of SMARTDROPLETS, the questionnaire targets key information concerning interfaces, data formats, and protocols. Within the digital ecosystem of SMARTDROPLETS, spraying machine manufacturers wield significant influence, driving sectoral innovation. Consequently, the insights gleaned from this survey are invaluable in delineating the technical dimensions of machine interoperability throughout the project lifecycle.

1.1 Purpose, context, and scope of this deliverable

The SMART DROPLETS project aims to advance both hardware and software capabilities during chemical applications for resource optimization and minimization of chemical waste. To accomplish this vision, this project will use already existing technologies (>TRL 7) developed within but not limited to the agricultural industry. Its ultimate aspiration is to deliver a complete system capable of translating large amounts of data from the field into meaningful information and impactful spraying commands to achieve the Green Deal goals.

The purpose of this deliverable is to give a systematic formalization of a set of relevant specifications, necessary to the deployment of the pilot’s projects. Technical metrics 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.

These requirements will guide the development phases within the technical work packages, and therefore, this deliverable will be the first common source of user requirements for the SMART DROPLETS consortium. The list of requirements in this document reflects the work performed in Tasks T2.1 – “User requirements and measurable metrics” and emerged from the interview and questionnaires processes conducted with representatives from the spraying machinery industry.

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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. The main analysis of this deliverable is related to:

a) compilation of current industry related needs, and well-defined metrics to address economic, agronomic, technical, and environmental needs.

b) requirements analysis on economic, agronomic, such as yield production, quality assessment, number of field operations, reduction of spraying drift, accuracy of spraying application.

c) establishment of the targeted data functions for the Smart Droplets Data Management Platform.

In order to collect and analyze the requirements we worked in the following axis:

- Questionnaires targeting all actors in the data farming ecosystem.
- Interviews with respective industry representatives
- Collection and analysis of requirements from previous respective initiatives
- Requirements from the use case participants representing the two uses of case selected.

The final expected outcome of Task 2.1 will be the successful implementation of a data which will be evaluated by two specifically designed use cases, carefully selected from two different crops scenarios.

These use cases are:

- UC1: The apple demonstrator
- UC2: The wheat demonstrator

The development of this deliverable was coordinated by FEMAC with mainly contribution of AgriFood Lithuania DIH (AFL), Agricultural University of Athens (AUA), and the rest of the consortium members.

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.

1.3 Deliverable Overview and Report Structure

This deliverable belongs to WP2 - Ecosystem Mapping & Training, which is dedicated to establishing the framework for a structured and sustained dialogue with a range of stakeholders, including user industries, in both technical and training aspects of the project.

Within the Work Package, more specifically, tasks T2.1 and T2.2 are focused on identifying and collect industry needs as well as technical, economic, environmental requirements; define a robust set of Key Performance Indicators (KPIs) to be evaluated and monitored; and develop and formulate environmental, economic, social assessment of the robotic system ensuring its adaptability and thus, versatility to sectoral needs; and Task 2.3 on recruiting, educating and training domain experts on the topics of AI, ethics in AI, Data and Robotics.

D2.1 consists of 9 chapters, in which the adopted elicitation processes and the project requirements defined at the end of the first cycle of elicitation have been described, as follows:

- General description of the scope and objective of the deliverable [Chapter 1]
- Definition of the methodologies for the identification of the SMART DROPLETS industry requirements [Chapter 2]
- Definition of the SMART DROPLETS Objectives Context for the requirements [Chapter 3]
- Current data farming practices and industry needs [Chapter 4]
- Related legal and regulatory frameworks [Chapter 5]
- Requirements emerging from Use Cases [Chapter 6]
- Consolidation of requirements [Chapter 7]
- Stakeholders mapping [Chapter 8]
- Conclusions and next steps [Chapter 9]

2 Methodology

The SMART DROPLETS project is based in a user centered approach, which places the stakeholders of a product or a system at the center of its design and development. User centred design (UCD) seeks to answer questions about users and their tasks and goals, in our project, such as "who are the users of the metrics collected through a Farm Management Information Software (FMIS)?", "what are user tasks and goals?", "what expectations do farmers have from collecting this data through a FMIS?". The answers to these questions are then used to drive the design and development. This is achieved by involving and talking directly to key stakeholders throughout the project, to assure that the future SMART DROPLETS platform will deliver the foreseen requirements.

The means to collect the industry needs and requirements are through:

1. key stakeholders' interviews
2. the use of dedicated electronic surveys
3. the analysis of selective related data
4. the analysis of related legal framework

The context, in which the requirements are analyzed, is also part of the deliverable 2.1 objectives.

The methodology to produce and use the SMART DROPLETS data is illustrated in Figure 1. In particular:

- All requirements' sources are analyzed for individual requirements and their justification.
- The above-mentioned requirements drive the definition of the Functional Requirements, which will be used for the implementation of the Smart Droplets data management platform (WP3), the Intelligent Spraying and Direct Injection System (WP4) as well as Autonomous Robotic Spraying System reference architecture (WP5)
- To assist implementation, each FR is mapped to the respective project task.
- Furthermore, the FRs will be used by the methodology for deploying the two uses cases. WP 5

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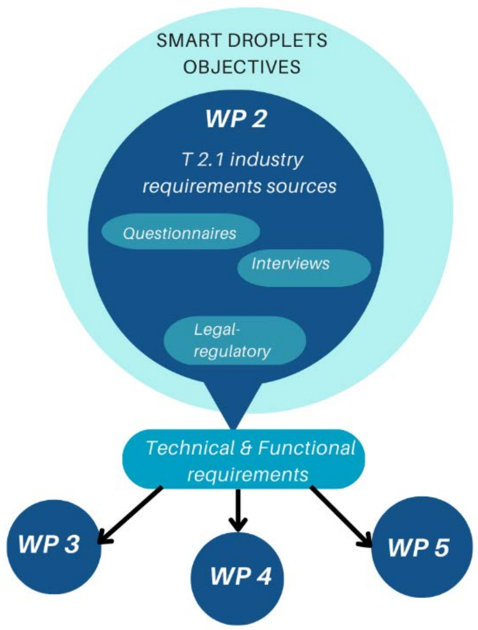

Figure 1: Methodology for the requirements elicitation, analysis and usage

This process is depicted in the implementation of task 2.1 User Requirements and measurable metrics (M01-M06).

3 SMART DROPLETS Objectives Context for the requirements

The main objective of the SMART DROPLETS project is summarized as follows:

Smart Droplets' main objective is to advance both hardware and software capabilities during chemical applications for resource optimization and minimization of chemical waste. To accomplish this vision, this project will use already existing technologies (>TRL 7) developed within but not limited to the agricultural industry. Its ultimate aspiration ***is to deliver a complete system capable of translating large amounts of data from the field into meaningful information and impactful spraying commands*** to achieve the Green Deal goals.

Smart Droplets main objective will be achieved by realizing the following Key Objectives (KO):

KO#1: Innovate using intelligent (non-robotic) Data infrastructure and Digital Twins, which will play an instrumental role in analyzing field data about crop growth and enemies' expansion, while recommending optimal spraying strategies, which will bring the solutions ready to practice.

KO#2: Integrate robotic (physical) solution for autonomous spraying to address the challenge of resource optimization and waste minimization, targeting chemical and nutrient over-application and natural resource (water, soil) exploitation during crop care tasks.

KO#3: Optimize technologies and demonstrate the Green Deal goals in real life environments through two demonstrators in apple and wheat farms over 2 growing seasons.

KO#4: Community building, synergies, and results exploitation through building strategy that includes training programs, visual identity and communication channels, digital and physical platforms for interaction among members.

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REMARKS

- In the requirements elicitation process both farmers and industry representatives provided requirements through interviews and background information.
- The legal framework for pesticide and fertilizer data collection is analyzed.

Relevant to this task is SMART DROPLETS part of objective 1:

Objective 1	Tas 2.1 Industry Needs & Requirements Analysis
To analyze requirements specifications for the Smart Droplets system to be deployed on the two demonstrator cases. The requirements will cover the data infrastructure, the robotic platform, and the implement (sprayer).	
Achieving this objective will require capturing and eliciting **industry requirements**, as well as a detailed analysis of **end-user data needs** in view of transforming these into specific functional requirements and an architectural design.	
Measurable outcomes: 1. Detailed industry-specific technical and functional specifications appropriate for a data management linked to specific target KPIs considering the prerequisites for pilot planning in WP5 starting by M09.	

4 Current data farming practices and industry needs

Data farming refers to the practice of collecting large amounts of farming data from a variety of sources to extract valuable insights and knowledge. This data can come from a variety of sources, including sensors, and other types of digital records. The data collected through Farm Management Information Software (FMIS), can be used to track a wide range of information, including financial data, production data, inventory, and weather data, but also can help farmers plan and schedule tasks such as planting, harvesting, and maintaining equipment, but the most important outcomes, will be the data analysis, the FMIS used for analyzing data and generate reports that help farmers make informed decisions about their operations.

The FMIS are used to optimize and manage farm operations and production activities. The software is usually customized to meet specific farm requirements since each firm has activities that are carried out. Regarding our work, we will focus on the use of FMIS for tracking the most appropriate pest control method to use, and the best fertilizer to apply. There are several numbers of companies, Global but also local, that offer a variety of possibilities that helps farmers monitor farm yields with ease.

But the reason why FMIS are more and more extended among the EU farmers, it is because it represents a shift from the paper agricultural field notebook to the digital agricultural field notebook.

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An agricultural field notebook (AFN) is a tool used by farmers, agricultural professionals, to document a wide range of information, including weather data, soil conditions, pest and disease control measures, and crop growth and development, and this data has to be shared with the correspondent agricultural ministry of each country to unify the existing records in the public administration in agricultural matters to integrate the information that farmers must provide to the competent authorities.

All farmers, according to current legislation and regulations, have the obligation to have and keep updated a field notebook that records certain activities but, at a time when everything has been converted to digital, field notebooks are no less. However, a good field notebook can go beyond the legal requirements that may be required of the farm owner.

A detailed and exhaustively completed field notebook allows to control the agricultural exploitation, manage it and analyze its productive data. It helps us to detect problems in it and to know how to organize ourselves for other campaigns, helping us to improve processes for comprehensive management of the farm.

As we can see both, AFN and FMIS, are currently the main tools farmers uses to collect the following data:

1. **General data on the crop in each agricultural plot.** Additional information will also be provided, such as planting date and harvest date.
2. **Production data at the level of each agricultural plot**. It will be necessary to indicate the harvest in Kg. / Hectare, as well as the destination of the production and of the vegetable remains. In the case of the vineyard, the winery receiving the grapes must be identified and located.
3. **Phytosanitary treatments**. It is necessary to indicate the actions that are carried out in each plot, as well as the possible use of treated seed or post-harvest applications. It will be necessary to enter the data of the products used as well as the applicator, the machinery, and the adviser.
4. **Fertilization.** The date of application, the fertilizing material used, as well as its composition in organic carbon, macronutrients and micronutrients must be indicated. The subscriber plan will also be attached, and the advice received will be identified.
5. **Irrigation.** The irrigation date, the system used, and the surface reached will be identified. Also, the origin and amount of water used.
6. **Marketed harvest.** The product and the date on which the sale is made will be identified.
7. **Analytics,** if any.

In the other hand, there are several requirements that spraying machinery manufacturers may need to meet to produce and sell their products to farmers, that in chapter 7 will be explained.

Agricultural spraying machines manufacturers are including machinery equipped with connectivity features that allow them to communicate with other devices and systems. This connectivity can enable a range of benefits, that can control and monitoring remotely allowing farmers and other operators to track the performance of the machinery and adjust as needed, especially data collection and analysis, they can collect data about their performance and the environment in which they are operating, which can be used to inform decision-making and optimize operations. Connected spraying machines may use a variety of technologies to communicate with other devices, including Wi-Fi, cellular, and satellite networks. In some cases, these machines may be part of larger connected systems that include other sensors, devices, and software tools for data management and analysis, and they may be able to adjust their spray patterns or flow rates based on real-time data about the crop and environment.

Industry is concern as well for the enhanced safety, spraying machinery manufacturers may need to ensure that their products meet safety standards to protect the operators and users of the machinery. This may include designing machinery to minimize the risk of accidents and injuries, and including safety features such as guards, warning labels, and emergency shutdowns.

Also praying machinery manufacturers may be subject to environmental regulations that govern the emissions and waste produced by their products. These regulations may include limits on the levels of pesticides and other chemicals that can be released into the environment, as well as requirements for managing and disposing of hazardous materials.

Spraying machinery manufacturers may need as well, to have quality control processes in place to ensure that their products meet certain standards of performance and reliability. Mostly of the machines that are working in the field, need some testing and inspecting during their performance realized by authorized government safety agencies.

5 Related legal and regulatory frameworks

This Task 2.1 aims at analyzing the legal and regulatory framework for respective requirements to:

- Understand the legal framework that regulates the type of data government agencies are requiring from the industry and from the farmers.
- develop a data management platform and the respective operational procedures compliant to all respective data privacy and free flow regulations aiming at commercial exploitation of the service.

The use of pesticides is regulated by several legal and regulatory frameworks at the national, regional, and European levels. These frameworks are designed to protect human health and the environment by setting standards for the use, handling, and disposal of pesticides. Some examples of legal and regulatory frameworks related to pesticides include Pesticide registration, where pesticides must be registered with a government agency before they can be sold or used. The registration process typically involves evaluating the safety and effectiveness of the pesticide, as well as its potential risks to human health and the environment.

Through the AFN, government agencies require controlling the Pesticide application. There are often rules and regulations governing the application of pesticides, including restrictions on where and when they can be used, and requirements for protective equipment and training for applicators.

Since second half of 2023, the digital AFN will be mandatory to all EU members, and the objective of this measure is to ensure that all agricultural companies use the digital farm notebook before ending 2023. Being digitized will be essential for communication with the institutions and to be able to access Common Agricultural Policy (CAP) aid. The new system will be implemented progressively in collaboration with the EU members.

Farmers will record information about their crops and the use they make of the different products, whether they are phytosanitary products or fertilizers.

Efficient management of the CAP following the system of indicators of the "New Delivery Model" and compliance and monitoring of the strategies "from farm to table" and biodiversity, within the green pact. Enable efficient planning, execution and management of the CAP 2023/2027 and contribute to the evaluation of compliance with the Strategic Plan of the CAP 2023/2027 following the system of indicators of the new management model that makes up the performance framework, according to chapter I of title VII of Regulation (EU) 2021/2115 of the European Parliament and of the Council, of December 2, 2021, which establishes rules in relation to aid for strategic plans that Member States must prepare within the framework of the common agricultural policy (strategic plans for the CAP), financed by the European Agricultural Guarantee Fund (EAGF) and the European Agricultural Fund for Rural Development (EAFRD), and which repeals Regulations (EU) No. 1305/2013 and (EU) No. 1 307/2013.

Commission Directive (EU) 2019/782, of May 15, 2019, which modifies Directive 2009/128/EC of the European Parliament and of the Council regarding the establishment of harmonized risk indicators, it establishes the obligation of the Member States to publish the data of harmonized risk indicators.

A harmonized risk indicator can only be based on statistical data collected in accordance with Union legislation on statistics on plant protection products and other relevant data, and in the absence of these, the only relevant and currently available data are statistics on the marketing of phytosanitary products and the number of authorizations granted in special circumstances.

Each EU member is responsible for calculating the harmonized risk indicators, which will be made public annually through their corresponding official websites. The aim of the new regulation is twofold. On the one hand, Agriculture wants to simplify procedures and controls related to the Common Agricultural Policy (CAP) and even plans to send each farm a draft of its CAP, to facilitate its presentation, in the image of what the Ministry of Finance with the income statement.

Secondly, **the Administration seeks to have access to the monitoring of indicators such as the use of fertilizers, phytosanitary products, or medicines in each farm**. In this way, it will be able to verify if the Spanish countryside is advancing in the objectives set out in documents such as the CAP National Strategic Plan, the European Green Pact or the from farm to table strategy. The EU thus seeks to ensure that EU improves in terms of more respectful productions with the environment and with the conservation of biodiversity.

6. Requirements emerging from Use Cases

As all work conducted in SMART DROPLETS is use-case driven, most of the requirements is evolving from the concrete use cases of the end-users. For each use case, the perspective of the three main actors subject to interoperability are considered: Spraying machines, sensors, and data processing services. In this respect, the term “spraying machine” refers to as a sprayer, is a piece of equipment used in farming to apply pesticides, herbicides, fertilizers, or other chemicals onto crops. These machines are designed to distribute the desired substance efficiently and evenly over a large area of land. The term “sensor” refers to any third-party sensor attached to the machine; in the concrete use cases it is mostly the multi-sensor system. The term “data processing service” refers to any software which delivers calculations based on sensor or machine data.

The following stakeholders have been identified as key for the realization of the SMART DROPLETS solution:

- **Farmer**: Owner of farming business.
- **Contractor**: Owner of farm equipment that operates those as a service for farmers.
- **Operator**: Operator of farm equipment

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- **Machine Manufacturer**: Manufacturer of farm equipment
- **Service Provider & Agronomist**: Provider of services to the farmer such as agronomic advice or bookkeeping.
- **Dealer**: Seller of farm equipment and ag-related services (e.g. maintenance, consulting, support)
- **FMIS provider**: Provider of software solutions for farming business management
- **Governmental Authority**: Statistical offices and economic departments and agencies which monitor agronomical regulation.
- **Technology Provider**: Platform Provider (not connected to OEMs / Clouds)
- **Input Provider** (agricultural chemical industry): Producer and seller of fertilizer and chemicals.
- **Input Provider** (trader): Owner of trading business (sell inputs and buy the outputs)
- **Food Processor**: Buyer and processor of harvested goods

Section 8. provides a comprehensive breakdown of their complete attributes, objectives, limitations, and responsibilities. Armed with this understanding, the subsequent sections of this report delve into the formulation of use cases.

To accommodate the diverse needs of the two distinct use cases, an initial step involved conducting consultation sessions and interviews with relevant stakeholders. These interactions informed the development of the SMART DROPLETS use cases, outlined *in 'D2.6-Industry needs and end-user(farmers) requirements V2.* Subsequently, a range of functional and technical requirements were extrapolated from these use cases and are presented within this document. Requirements deemed specific to the implementation of a particular use case, and not impacting the overall architecture, are marked as "n/a". Central to this investigation are inquiries into existing data sharing requirements within the agricultural sector and their relative significance. The authors of this report document their research efforts towards consolidating a comprehensive list of requirements, drawing from both the SMART DROPLETS use cases and broader non-functional requirements essential for the operational efficacy of the SMART DROPLETS Platform and in alignment with the EU data strategy. The primary focus of this endeavor lies in deriving technical solutions to fulfill these consolidated requirements, serving as a foundational framework for the eventual implementation of the SMART DROPLETS Architecture.

6.1 Farmer's Use Cases

In the subsequent sections, we outline the requirements that have arisen from the collaborative development of use cases with our farming partners within the consortium in Spain and Lithuania.

6.1.1 Appel Demonstrator

Smart Droplets introduces critical hardware and electronic components that **minimize latencies and dosing inconsistencies** during the DIS functioning. More importantly, hydraulic circuits will be integrated for efficient chemical injection in the outlet section and chemical dosing mechanisms in each compartment will be configured for accurate delivery of solid and liquid state compounds,

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considering different viscosities. AGROMA, with more than 40 years' experience in manufacturing agricultural implements, will upgrade the CYCLONE TT2 2000L mist blower for apple demonstrators. The selection of chemicals that DIS will be optimized on, will be driven by the frequency, environmental impact and total amount applied in each spraying application in Spain.

The goal then, of this use case is to **minimize latencies and dosing inconsistencies** during the DIS functioning. Different data points will be processed online on the machine, the result will be georeferenced using the machine's positioning systems and written to different maps.

Plant protection should be applied targeted depending on the leaf area and plant damages. The true novelty of the Smart Droplets solution is achieved by **linking sprayers with the intelligence stack**, that is leveraging Digital Twins and AI models. **Field awareness** before the tractor and sprayer deployment, can allow a probabilistic planning of the spraying and chemical selection based on AI models and the Digital Twin information, therefore diminishing application gaps, latencies and off-target spraying. Cameras mounted on the sprayer will validate Digital Twin's prediction and fine-tune the dosage recommendations in real time. A maximum of 5 chemicals on different states and viscosities will be accommodated in the DIS, **claiming savings of 40% in Plant protection Products (PPPs), 15% in nutrients and 50% in overall water use.** The solution comprises a dedicated spraying application which runs on the machine and controls the sprayer, and an associated cloud service which implements the connection to the SMART DROPLETS interoperability network.

Table 1 Functional requirements for Use Case – DIS and intelligent spraying in apple fruits.

Requirement	consolidated requirement
The machine necessitates a specialized spraying calculation application to operate effectively.	C1
Spraying application has the capability to control sprayer (e.g. via ISOBUS)	C1
Remote setup of the spraying application, including vehicle configuration, sprayer settings, and plantation parameters, must be achievable through the Farm Management Information System (FMIS).	C3
The on-board spraying application needs to offer a user interface for easy interaction and control.	C3
The spraying application should offer a control interface, allowing users to manage the sensor box functionalities, such as initiating or halting scanning operations.	C2
A fully integrated system capable of transforming extensive field data into actionable insights and effective spraying strategies.	C2
A set of implements allowing a safe autonomous vehicle, including safe positioning solution and real time monitoring	C18
3D Multi-sensor GNSS-enabled localization and mapping for safe navigation in outdoor agricultural environments	C20

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Sprayer with a Direct Injection System - Real-time chemical injection system for variable rate spraying based on ISO and agricultural standards	C9/C14/C16
Spraying application needs access to position and speed data	C4/C20
Spraying application needs to collect data for documentation (amounts of applicants used, position of diseases)	C21
AI models, digital twin, and robotics interfaces. Communications middleware and data models for digital platforms and robotics systems interoperability	C21

Table 2 Technical requirements for Use Case – DIS and intelligent spraying in apple fruits.

Requirement	consolidated requirement
The sensor box must possess onboard processing capabilities to handle LIDAR and image data effectively.	C20
The sensor box should be outfitted with onboard GPUs to ensure efficient processing of data with high performance.	C20/C21
The spraying application must be able to exchange data with the sensor box	C21
A modular user interface is essential to enable users to configure the tractor, sprayer, and plantation settings efficiently.	C2/C4
The spraying application should be compatible with the necessary communication protocols required to control the sprayer effectively.	N/A

6.1.2 Wheat Demonstrator

Smart Droplets introduces critical hardware and electronic components that **minimize latencies and dosing inconsistencies** during the DIS functioning. More importantly, hydraulic circuits will be integrated for efficient chemical injection in the outlet section and chemical dosing mechanisms in each compartment will be configured for accurate delivery of solid and liquid state compounds, considering different viscosities. AGROMA, with more than 40 years' experience in manufacturing agricultural implements, will upgrade the INNOVATOR 3000/24m boom sprayer for winter wheat demonstrators. The selection of chemicals that DIS will be optimized on, will be driven by the frequency, environmental impact and total amount applied in each spraying application in Lithuania.

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The goal then, of this use case is to **minimize latencies and dosing inconsistencies** during the DIS functioning. Different data points will be processed online on the machine, the result will be georeferenced using the machine's positioning systems and written to different maps.

Plant protection should be applied targeted depending on the leaf area and plant damages. The true novelty of the Smart Droplets solution is achieved by **linking sprayers with the intelligence stack**, that is leveraging Digital Twins and AI models. **Field awareness** before the tractor and sprayer deployment, can allow a probabilistic planning of the spraying and chemical selection based on AI models and the Digital Twin information, therefore diminishing application gaps, latencies and off-target spraying. Cameras mounted on the sprayer will validate Digital Twin's prediction and fine-tune the dosage recommendations in real time. A maximum of 5 chemicals on different states and viscosities will be

Table 3: Functional requirements for Use Case – DIS and intelligent spraying in wheat.

Requirement	consolidated requirement
The machine necessitates a specialized spraying calculation application to operate effectively.	C1
Spraying application has the capability to control sprayer (e.g. via ISOBUS)	C1
Remote setup of the spraying application, including vehicle configuration, sprayer settings, and plantation parameters, must be achievable through the Farm Management Information System (FMIS).	C3
The on-board spraying application needs to offer a user interface for easy interaction and control.	C3
The spraying application should offer a control interface, allowing users to manage the sensor box functionalities, such as initiating or halting scanning operations.	C2
A fully integrated system capable of transforming extensive field data into actionable insights and effective spraying strategies.	C2
A set of implements allowing a safe autonomous vehicle, including safe positioning solution and real time monitoring	C18
3D Multi-sensor GNSS-enabled localization and mapping for safe navigation in outdoor agricultural environments	C20
Sprayer with a Direct Injection System - Real-time chemical injection system for variable rate spraying based on ISO and agricultural standards	C9/C14/C16
Spraying application needs access to position and velocity data	C4/C20
Spraying application needs to collect data for documentation (amounts of applicants used, position of diseases)	C21

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AI models, digital twin, and robotics interfaces. Communications middleware and data models for digital platforms and robotics systems interoperability	C21

Table 4 Technical requirements for Use Case – DIS and intelligent spraying in wheat.

Requirement	consolidated requirement
The sensor box must possess onboard processing capabilities to handle LIDAR and image data effectively.	C20
The sensor box should be outfitted with onboard GPUs to ensure efficient processing of data with high performance.	C20/C21
The spraying application must be able to exchange data with the sensor box	C21
A modular user interface is essential to enable users to configure the tractor, sprayer, and plantation settings efficiently.	C2/C4
The spraying application should be compatible with the necessary communication protocols required to control the sprayer effectively.	N/A

6.2 Agricultural Customer Use Cases Identified within Industry and contractors.

In the following sub-sections, the use cases proposed in 'D6.1 End-use Requirements' by the industrial partners, teamed up in the FEMAC[1] and the ANSEMAT[2], are further elicited. In the present report, the first mapping performed was between the functional and technical requirements.

Agricultural Customer Use Cases Identified within Industry and Contractors refers to the specific scenarios or applications identified by professionals within the agricultural industry and contracted experts. These use cases typically entail various aspects of agricultural operations, such as crop management, pest control, irrigation, harvesting, and machinery utilization. The aim is to identify practical solutions or strategies that address the needs and challenges faced by agricultural customers, ultimately enhancing productivity, efficiency, and sustainability in crop protection practices. These identified use cases serve as a foundation for developing and implementing the two uses cases foreseen.

The requirement elicitation was based on the following logical steps:

1. Identification and talks to the stakeholders (Industry associations, entrepreneurs, ..)

[1] FEMAC. The Catalan Cluster of agricultural Machinery – FEMAC

[2] ANSEMAT - Asociación Nacional de Maquinaria Agropecuaria y Espacios Verdes - ANSEMAT

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2. Identification of use cases after consultation of several technical and after services sales departments from Industry members
3. Selection of the goals for both (apple and wheat) use cases
4. Definition of use case-specific pre-conditions (functional, non-functional, technical)

6.2.1 Track guidance system

The Spraying machine tracking solution provided by SMART DROPLETS acts as a comprehensive online platform designed specifically for farmers and contractors who oversee diverse fleets. It smoothly integrates with current telemetry solutions or portals, granting users the convenience of managing their entire mixed machinery fleet through a preferred single system. This eliminates the need to navigate multiple OEM portals, providing a streamlined approach to fleet management. In this scenario, SMART DROPLETS members offer their assistance to testers engaged in apple and wheat demonstrator.

Table 5: Functional requirements for Use Case – Machine tracking

Requirement	consolidated requirement
Every measurement must come with a timestamp to give the displaying system the possibility to show the user when the measurement was taken.	C2
Each measurement must include coordinates to allow the displaying system to accurately depict the location where the measurement was obtained.	C2/C4
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.	C2/C3
The system shall support information about the machine to enable the user to identify the machine. Identification attributes are made, model, type	C2/C3
The system shall support a functionality which allows the user to access historical data.	C2/C3
The system must ensure that only the owner can give access to the machine data.	n/a
The system must offer a designated unit of measure for each attribute to ensure accurate display of the information.	C2/C3
The system shall provide the measurement rate, unit, and bit resolution for every attribute (in reference to ISO 11783)	C2, C10
The system shall be able to limit the accessibility of a machine to a certain timeframe.	C2/C3
The system shall provide a functionality to search and add a machine to the used system to receive telemetry data.	C4

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The hosting system of the connected equipment should provide information about the supported capabilities.	C2/C3/C4
The system shall provide a means to uniquely identify a machine to simplify the process of machine identification for the end-user.	C3
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.)	C2

Table 6: Technical requirements for Use Case – Machine tracking

Requirement	consolidated requirement
The timestamp sent along with any measurement should adhere to the Coordinated Universal Time (UTC) standard, following the ISO 8601 format.	C2
The coordinates (sent along with any measurement) shall consist of a latitude, a longitude and an elevation value conforming to the reference coordinate system World Geodetic	C2/C3/C7
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).	C7
The system shall support a functionality to receive tracking data from a specific endpoint.	C7
The system shall be able to uniquely identify endpoints.	C2
The system shall support a functionality to check the tracking data exchange capability of an endpoint.	C3
The system shall support that tracking data (or its subpart) can be sent to many endpoints.	C7
The system shall use standard data formats to exchange tracking data.	C4
The system shall ensure that tracking data is exchanged only among granted endpoints.	C2
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.	C3
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.	C7
The receiving endpoint shall verify if it is the correct recipient of the tracking data, to accept or refuse it.	C3

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The system shall support a functionality to inform the receiving endpoint about the availability of new tracking data.	C3
The system shall support the listing of available endpoints to allow configuration for the equipment owner.	C3
The sending system shall buffer the tracking data for a limited time in case the recipient endpoint is temporarily not able to receive them.	C3

6.2.2 Online task management

As quoted in 'D6.1-End-user requirements':

For individuals engaged in agriculture, equipment operation, and agricultural software utilization, online task management enables the real-time exchange of data concerning both past and current field tasks. It fosters smooth communication among different data platforms linked to a diverse range of interconnected machines.

Table 7: Functional requirements for Use cases. Online task management

Requirement	consolidated requirement
The user should have the capability to dispatch a Task Batch from their preferred agricultural software directly to the spraying machine.	C3
The user must be capable of receiving the Task Batch results from the spraying machine within their chosen agricultural software.	C3
The machine owner shall be able to define the agricultural software to exchange the Task Batch data with.	C3
The user of the agricultural software shall be able to select the explicit machines to send the Task Batch to.	C3
The user of the agricultural software must be able to clearly understand from which machine the Task Batch is coming from.	C3
The user of the machine must be able to clearly understand from which agricultural software the Task Batch is coming from.	C3
The user of the agricultural software shall be able to verify if a specific machine is able to exchange Task Batch data.	C3
The user of the machine or of the agricultural software must be informed about the availab of a new Task Batch.	C3

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Standard data formats shall be used to exchange the Task Batch data.	C3
The Task Batch data shall be exchanged only among allowed agricultural software and machines.	C3
The Task Batch data exchange must be protected to avoid unwanted data corruption and to assure data privacy.	C3
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)	C3
The user shall be able to see the task status on the machine	C3

Table 8: Technical requirements for Use Case. Online task management

Requirement	consolidated requirement
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.	C4
The system shall support a functionality to receive Task Batch data from a specific endpoint.	C4
The system shall provide a means to identify in a unique way the endpoints.	C4/C3
The system shall support a functionality to check the Task Batch data exchange capability of an endpoint.	C4/C3
The system needs to cope with the fact that one Task Batch (or its subpart) can be sent to many endpoints.	C4/C3
The system shall use standard data formats to exchange the Task Batch data.	C4/C3
The system shall ensure that Task Batch data are exchanged only among granted endpoints.	C4/C3
The Task Batch data must come with the information about the receiving endpoint (the recipient of the transmission).	C4
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.	C4

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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.	C4/C3
The receiving endpoint shall verify if it is the correct recipient of the Task Batch, to accept or refuse it.	C4/C3
The system shall support a functionality to inform the endpoint about the availability of new Task Batch.	C4/C3
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	C4/C3
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.	C4
The system shall support a functionality to inform the sending endpoint about the results of data transmission over the network.	C4
The system shall provide clear and common error messages or acknowledge messages, in order to implement a proper management of Task Batch data transfer.	C4
The system shall provide a means to buffer the Task Batch data, in case the recipient endpoint is temporarily not able to receive them.	C4/C3

6.2.3 Infield sensor connection

As quoted in 'D6.1-Industry needs and end-user(farmers) requirements':

Farmers benefit from monitoring field properties across various data platforms, enabling real-time infield data analysis encompassing weather conditions, field topography, crop vegetation indices, and soil conditions. This use case establishes the groundwork for seamless data communication among different platforms and IoT devices like infield sensors, all integrated with the preferred agricultural software solution.

Table 9: Functional requirements for Use Case – Infield sensor connection

Requirement	consolidated requirement
Each measurement should be accompanied by a timestamp to enable the displaying system to indicate the time at which the measurement was recorded.	C1

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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.	C1
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.	C1
The system shall support information about the sensor to enable the user to identify the sensor. Identification attributes are manufacture, model, type, serial number	C1
The system can support a functionality which allows the user to access historical data.	C1
The system must ensure that only the owner can give access to the sensor data.	C1
The system shall provide a unit of measure for each attribute which allows the user system to correctly display the information.	C1
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)	C1
The system should furnish the measurement rate, unit, and bit resolution for every attribute, following the guidelines outlined in ISO 11783.	C1
The system shall be able to limit the accessibility of a sensor to a certain time- frame.	C1
The system shall provide a functionality to search and add a sensor service to the used system of the user to receive sensor data.	C1
The system should provide information about the supported capabilities.	C1
The system shall provide a means to uniquely identify a sensor to simplify the process of sensor identification for the end-user.	C1
The system shall provide a location and type description for each sensor measurement.	C1

Table 10: Technical requirements for Use Case – Infield sensor connection

Requirement	consolidated requirement

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The timestamp (sent along with any measurement) shall be formatted conform Coordinated Universal Time (UTC), ISO 8601[3].	C4
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)	C4
The system shall support a functionality to send measurements to a specific endpoint or a group of endpoints.	C4
The system shall be able to uniquely identify endpoints.	C4
The system shall support a functionality to check service specific capability of an endpoint.	C4
The system shall use standard data formats to exchange the measurements.	C4
The system shall ensure that measurements are exchanged only among granted endpoints.	C4
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.	C4
The system shall support a functionality to inform the receiving endpoint about the availability of new measurements.	C4
The system shall support the listing of available endpoints to allow configuration for the equipment owner.	C4
The measurements must come with information of the sending endpoint, to enable the receiving endpoint to identify the endpoint of the measurements.	C1/C4
The system shall provide capabilities to several meta information (accuracy of coordinates, type, frequency, unit, geographic coordinates/location, measurement technology, time of historical data)	C4
The measurements sending endpoint shall provide authentication information to the receiving endpoint, to verify if the sending endpoint is allowed to send data to the receiver. (including access for a time period)	C1/C4

[3] ISO 8601 is an international standard for representing dates and times in a structured and universally understood format. It provides guidelines for the representation of date and time information in a way that is unambiguous, easily interpretable, and compatible with computer systems and applications.

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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.	C1/C4
The system shall provide a subscription to a subset of values for the receiving endpoint.	C4

6.2.4 Field data management

As quoted in 'D6.1-Industry needs and end-user(farmers) requirements':

For farmers, ensuring the interoperability of various machines and in-field sensors is crucial, as it allows for the generation of real-time information on ongoing processes. Examples include GIS-related data and yield information from different systems, which have traditionally been fragmented. Through this use case, such data is seamlessly integrated with utmost accuracy into the agricultural software used by individual users.

Table 11: Functional requirements for Use Case – Field data management

Requirement	consolidated requirement
The field data coming from machine or sensors shall be exchanged only among allowed agricultural software and service providers.	C2/C3
Standard data formats shall be used to exchange the field data.	C2/C3
The data exchange must be protected to avoid unwanted data corruption and to assure data privacy.	C2/C3
The farmer shall be able to aggregate, and display data related to a specific field of his/her choice.	C2/C3
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.	C2/C3
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.	C2/C3
The farmer shall be able to configure in the agricultural software of his/her choice, from which machine or sensors receive the field data.	C2/C3
The farmer/machine owner shall be able to select the time frame of field data measurements to be aggregated and displayed.	C2/C3

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The farmer/machine owner shall be able to see where the measurement in the field was taken.	C2/C7/C14
The machine owner shall be able to share the aggregated field data elaborated by the agricultural software of its choice with the agricultural software of the selected service providers.	C2/C3
The machine owner shall be able to share the field data coming from machines with the agricultural software of the selected service providers.	C2/C3
The machine owner shall be able to select, in the agricultural software of his/her choice, the service providers to exchange the data with.	C2/C3
The service providers shall be able to integrate the field data from the machine owner with additional field information for documentation.	C2/C3
The service providers shall be able to share with the machine owner the results of field data information integration.	C2
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.	C2

Table 12: Technical requirements for Use Case – Field data management

Requirement	consolidated requirement
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).	C4
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).	C4
The system shall support a functionality to receive field data from specific endpoints (endpoint could be a data platform).	C4
The system shall provide a means to identify in a unique way the endpoints.	C4
The system shall support a functionality to check the field data exchange capability of an endpoint.	C4
The system needs to cope with the fact that field data can be sent to many endpoints.	C4
The system shall use standard data formats to exchange the field data.	C4
The system shall ensure that field data is exchanged only among granted endpoints.	C4

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The field data must come with the information about the receiving endpoint (the recipient of the transmission).	C4
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.	C4
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.	C4
The receiving endpoint shall verify if it is the correct recipient of the field data, to accept or refuse it.	C4
The system shall support a functionality to let the machine owner to select the endpoints the field data will be shared with.	C4
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.	C2/C4
The system shall support a functionality to inform the sending endpoint about the results of data transmission over the network.	C4

The spraying machinery sector is shifting towards more selective treatment applications to improve the quality and efficiency of chemical spraying. Smart Droplets will bring such models closer to commercialization, by linking the most recent advances in AI (e.g. CNNs, Autoencoders), with additional data sources (e.g. historic data) to increase the prediction accuracy and robustness. In Smart Droplets, data interoperability, warehousing and exploitation by AI models is crucial to support large-scale demonstrators and continuously monitor and refine big amounts of field data. Digital Twins and AI models will play an instrumental role in analyzing field data about crop growth and enemies' expansion, while recommending optimal spraying strategies, which will bring the solutions ready to practice, achieved by a Data Platform with proper agri-data models, processes, interfaces and process-based and AI models to recommend actions and estimate agronomic, environmental and economic impact as well as AI models at the "edge" for real time crop monitoring.

Table 13:field Data Requirements

VARIABLE	FRECUENCY
Field identification	
Field id	Per field
Group of fields id	Per field
Field cover area	Per field
Latitude	Per field
Longitude	Per field
Field properties	

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Elevation	Per field
Cultivar	Per field
Surrounding crop, activities, streets etc	Per field
Percentage of clay in soil	Per field
Percentage of sand in soil	Per field
Percentage of silt in soil	Per field
Percentage of loam in soil	Per field
Soil-plant available water capacity	Per field
Historical common pest type	Per field
other management practises (mechanical weeding, nets to protect crops, etc.)	Per field
Historical yield	For each harvest, per field
Field initial conditions	
Previous crop type	Per field
Initial soil nitrogen content	Per field
Initial soil-water / moisture	Per field
Irrigation management	
Irrigation treatment (on/off)	Per field
Irrigation type	Per field, per event
Irrigation date	Per field, per event
Irrigation amount	Per field, per event
Weather	
Maximum temperature	Daily, per field
Minimum temperature	Daily, per field
Precipitation sum	Daily, per field
Potential evapotranspiration	Daily, per field
Average radiation	Daily, per field
Average vapor pressure	Daily, per field
Average relative atmospheric humidity	Daily, per field
Average wind speed	Daily, per field
Biophysical properties	
Soil temperature at 300 mm depth	Daily, per field
Soil water stored from 0 to 300 mm depth	Daily, per field
Soil mineral nitrogen stored from 0 to 300 mm depth	Daily, per field
Leaf area index live leaves	Daily, per field
Leaf area index dead leaves	Daily, per field
Fruit/yield weight	Daily, per field
Fertilization events	
Fertilization date (day, month, year)	For each nitrogen application, per field
Fertilizer amount	For each nitrogen application, per field
Fertilizer type (percentage of n, urea …)	For each nitrogen application, per field

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Nitrogen content in crop	Any available frequency or final content
Fertilizer cost	Per field
Pesticide application events	
Reason for pesticide application (proactive, to fight pest…)	For each pesticide application, per field
Severity of plant disease before pesticide application	For each pesticide application, per field
Severity of plant disease after pesticide application	For each pesticide application, per field
How many days after pesticide application there was improvement	For each pesticide application, per field
Pesticide application date (day, month, year)	For each pesticide application, per field
Pesticide amount	For each pesticide application, per field
Pesticide type (percentage of each compound)	For each pesticide application, per field
Pesticide practises (protective net, bees, mechanical weeding)	Per field, per event
Pesticide cost (annually?)	Per field
Sowing	
Sowing data	Per field
cultivar	Per field
planting density	Per field
planting depth	Per field
Development stages	
Sowing data	Per field
emergence date	Per field
anthesis	Per field
other wheat development stage format (sequence like 1,2,3... etc.)	Per field
Harvest	
Harvest date (day, month, year)	For each harvest, per field
Yield amount	For each harvest, per field
Nitrogen content in harvested yield	For each harvest, per field
Expected yield amount	For each harvest, per field
robotic equipment photos (drones?)	Per flight or application etc.
other sources of data	

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7. Consolidation of requirements

Within this section, the consolidated requirements evolving from the use case-specific requirements (see section 6.1) and from the general non-functional requirements (see section 6.2). We captured the essence of specific use-case requirements into more general consolidated requirements. These consolidated requirements are ultimately used to drive and validate the architecture defined in WP3.

Table 14: Consolidated Requirements

No.	Requirement
C1	Precision Spraying Capability: The machine should have the ability to precisely target specific areas or crops, minimizing pesticide usage and reducing environmental impact.
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
C3	Compatibility with Agricultural Software Systems: Seamless integration with existing agricultural software solutions for task management, data analysis, and reporting
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.
C5	Adherence to Environmental and Safety Standards: Compliance with regulations and standards for pesticide application, ensuring safe and environmentally friendly operation.
C6	Efficiency in Pesticide Usage: Optimization of pesticide usage through advanced algorithms and techniques to minimize waste and reduce costs.
C7	Autonomous Operation or Remote Control: Capability for autonomous operation or remote control, allowing farmers to manage spraying tasks efficiently and conveniently.
C8	Adaptability to Different Field Conditions and Crop Types: Versatility to adapt to various field conditions, terrains, and crop types, ensuring optimal performance across different
C9	Precision Delivery: The DIS system must be capable of delivering precise amounts of pesticides directly to the target area with high accuracy and repeatability.
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.
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.
C12	Minimization of Environmental Impact: DIS systems should minimize environmental impact by reducing pesticide drift, runoff, and overall usage, thus promoting sustainable agricultural practices.
C13	Safety Features: Safety features such as automatic shut-off valves, pressure sensors, and leak detection mechanisms are essential to prevent spills, leaks, or accidents during
C14	Ease of Integration: DIS systems should be easily integrated with existing agricultural machinery, such as sprayers or irrigation systems, to facilitate seamless operation and
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 compliance.

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

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8. Stakeholders mapping

Below is a comprehensive table detailing the attributes of various stakeholders considered in the development of feasible use cases within the SMART DROPLET Project.

Table 15: Description of stakeholders: Characteristics, Goals & Constraints and Task(s).

Stakeholder	Description	General Characteristics	Goals & Constraints	Task(s)
Farmer	**Owner of farming business**	Apple fruits: ▪ Mix fleet (equipment from more than one Manufacturer) ▪ Between 5 and 100 Ha ▪ Partially connected, (not completely covered by network) ▪ FMIS user (manage master data, guidance lines, etc.) ▪ User of mobile apps ▪ Client of a contractor (spraying and harvest) Willing to share data on a need-to-know bases. ▪ Seeks technologies that help him to be more efficient. Wheat (extensive crops): ▪ Mix fleet (equipment from more than one Manufacturer) ▪ Between 5 and 100 Ha ▪ Partially connected, (not completely covered by network) ▪ FMIS user (manage master data, guidance lines, etc.) ▪ User of mobile apps ▪ Client of a contractor (spraying and harvest) Willing to share data on a need-to-know bases.	Appel fruits: ▪ More efficiency ▪ Integrated view (one tool/dashboard) Better decision making. ▪ Full transparency ▪ Better cost control ▪ Free choice of tools to use Change of tools - no lock-in ▪ In control of his data (transparency and control) Seamless data exchange with externals like his contractor or input provider but in a controlled and need to know basis (this includes receiving e.g. yield information from the contractor for the farmers field). Wheat (extensive crops): ▪ More efficiency ▪ Integrated view (one tool/dashboard) Better decision making. ▪ Full transparency ▪ better cost control ▪ Free choice of tools to use Change of tools - no lock-in ▪ In control of his data (idem apple fruits)	Manages assets (Machines, implements, sensors, fields, guidance lines, etc.) Manages field operations (planning, monitoring, reporting, includes also trading inputs/outputs) Manages technical infrastructures Data exchange with public authorities Analytics (agronomic, financial, etc.)

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Machine Manufacturer	**Manufacturer of spraying equipment**	Specialized in a specific machine segment with focus on High value fruits (South of Europe, in particular Spain, Ital and Greec), and Specialized in extensive Crops (North of Europe, Germany, France, Poland) Offer telematics solutions on self-propelled equipment globally. OEM operated cloud providing access for the owner to his machines. OEM operated cloud as firewall around the machines OEM uses anonymized machine data for data driven engineering	**GOALS:** Sell connected and smart spraying machinery. Enable the customer to use the data provided by the machine in connected tools and vice versa enable data exchange of the FMIS with the machine (e.g. prescriptions) Bring machine data first into the OEM cloud before it goes out to other consumers. **CONSTRAINS:** Balancing the costs of research, development, manufacturing, and marketing with price sensitivity in the agricultural sector to offer competitive pricing while maintaining profitability. Adapting to evolving regulations and standards related to equipment design, emissions, safety features, and chemical usage, which may necessitate product modifications	Manages technical infrastructure (vehicle security, safety, etc.) Ensures legal compliance (e.g. GDPR) Ensures end-to-end data flow Enables future solutions for M2M communication in the field what will require firewalls on the machines
Service Provider & Agronomist	**Service provider such as agronomic advice or bookkeeping to the farmer**	Specialized in agronomics and in plant specialties, they know the processes in the field. Offering recommendations for integrated pest management (IPM) strategies, including pest identification, monitoring, and control measures to minimize crop damage and pesticide use. Specialized in bookkeeping aspects and reporting. Needs data of the machines and from the processes in the field (e.g. as applied maps, fuel consumption, time used, etc.) Needs access to Ensuring adherence to pesticide regulations and safety guidelines, including proper handling, storage, and disposal procedures to minimize environmental risks and protect human health.	**GOALS:** Sell their services based on the data provided by or to the farmer. Enables the farmer to take more informed decisions based on the data available; this includes likely agronomic, machine, and financial aspects. Don't care how the data gets to their tools if they can use them easily in their tools of choice. Online data exchange allows faster reaction and response with less information loss. **CONSTRAINS:** With digitalization of data processing, they afraid to loose role	Read agronomic results from the farmer organization / farmers cloud of choice for data analytics. Sends prescriptions and/or analytics results back to the farmers system Reads details of input and output factors (e.g. varieties, ingredients, etc.) from the farmers system for bookkeeping and reporting. Sends reports back to the farmers system. Needs access to data for generating reports on pesticide usage, application history, and compliance records for internal management, regulatory agencies, and certification purposes.

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Governmental Authority	**Statistics offices and financial departments**	Statistics offices use the data for aggregated reporting to identify the status and details of agriculture in a certain region. Statistics offices only care about numbers, not the person (farmer) behind the numbers. Economic and environmental departments use the data for compliance checking and subsidy payments. They need to know all details and who is behind the numbers, as it leads to actions (payment, taxes, etc.) Each country in Europe has both organizations. Some countries have more organizations based on regions. Statistics offices report to Eurostat based on European defined rules. Statistics offices can define themselves how they collect data. So, although the output to Eurostat is defined, multiple data collection methods are used. Statistics offices like accurate and timely reporting, pre-formatted and aggregated numbers, limited data sources and data directly from the source (i.e. the sensor system) Statistics offices don' t like to program different APIs and custom integrations to different manufacturers and OEMS. Many authorities have their own proprietary APIs. Big focus on fertilization and **plant protection;** and subsidies	**GOALS:** Fast and accurate reporting Gets data automatically from "a system" for efficiency and quality purposes. Pre-populates online forms. Reduces time on collecting data to free up time for analysis. Protects the privacy of the data source. Don't scare away data providers but look for win-win situations where the data provider needs to spend less time on reporting. **CONSTRAINS**: Reluctancy of farmers for too much bureaucracy.	▪ Collects data through on-line forms. ▪ Works together with data sources to agree on formats and data flows Does proof of concepts for future reporting processes with farmers. ▪ Willing to program data transformation tools to help data providers load data into the online forms. ▪ Processes the subsidy requests Provides public information (soil maps, field boundaries, obstacle locations like windmills, etc.)
Input Provider (Ag chem industry)	**Produce and sell fertilizer and chemicals**	Usually, large organizations, but also SMEs Have their own software solutions (Bayer: FieldView; Yara: CROPIO) Provides Backends with APIs for products	**GOALS:** Sells products. Wants plant and yield information for simulation models (data driven business) Wants simple and direct data exchange (i.e. standardized APIs)	Wants to get own lists of goods integrated into FMIS's Supports the customer.

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9. Conclusion and next steps

In the deliverable D2.1 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 a use of artificial intelligence in their product-solutions.

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 2.1 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.

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- **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 to set up a clear and strategic Dissemination, Exploitation and Communication

This work will be thoroughly analyzed in the deliverable D2.6 entitled ‘D2.6-Industry needs and end-user(farmers) requirements V2 which is due on M18.

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