D2.7 Pilot alignment and joint assessment report

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List of Abbreviations

Abbreviation / acronym	Description
AI	Artificial Intelligence
ADS	Agricultural Data Space
API	Application Programming Interface
DIH	Digital innovation Hub
DoA	Description of Action
DSS	Decision Support System
Dx.y	Deliverable number y belonging to WP x
EC	European Commission
EU	European Union
GPS	Global Positioning System
IDSA	International Data Spaces Association
IEC	International Electrotechnical Commission
KPIs	Key Performance Indicators
LPWAN	Low Power Wide Area Network
MCC	Mission Control Centre
ML	Machine Learning
NDVI	Normalised Difference Vegetation Index
OGC	Open Geospatial Consortium
RGB	Red, Green, Blue
RFMS	Robot Fleets Management System
ROI	Return of Investment
UAV	Unmanned Aerial Vehicle
UGV	Unmanned Ground Vehicle
US	United States
WP	Work Package

Executive Summary

This deliverable D2.7 presents the common methodology that is being followed to ensure the alignment between the three FlexiGroBots pilots, which are executed in four European countries in parallel by different teams and focused on various types of crops. It is the first outcome of task *T2.5 – Pilots' methodology, follow-up and alignment*. An updated interim version of D2.7 will be released in December of 2022, which corresponds to month twenty-four of the project, with the publication of D2.8. The final version D2.9 will be published in month thirty-six, at the end of the project.

From the beginning of the project in January of 2021, T2.5 has been the instrument to guarantee that the three pilots, one of them executed in two different countries, follow a common approach and similar timelines so that the development of the FlexiGroBots platform satisfies the requirements of all of them. To achieve this goal, each one of the pilots specified the corresponding use-cases following the standard *IEC 62559-2:2015 - Use case methodology*. They were also requested to describe exhaustively the datasets that were going to be collected, and the different systems used in the use-cases (e.g., devices, ground and aerial robots, platforms). This information was used to produce the project requirements and to guide the definition of FlexiGroBots platform architecture, which are reported in deliverable D2.2. The proposed methodology is one of the core elements of this deliverable.

Moreover, considering the features that are intended to be implemented in the FlexiGroBots platform regarding AI experiments, data sharing building blocks, geospatial images processing, highly reusable services and management of missions of heterogeneous multi robots' fleets, D2.7 also includes a detailed analysis of the mapping of these functionalities in each one of the three pilots.

With an eye to the future, the document includes a summary of the agile methodology that will be used during the second and third years of the project to execute the pilots, identifying the complete backlog of features, high-level planning and timeline. In addition, the list of Key Performance Indicators (KPIs) originally included in the Description of Action (DoA) are also decomposed for each one of the pilots, presenting the verification mechanisms that will be used to validate them.

In the next iterations of this document, the list of KPIs will be updated considering the progress achieved during the project lifecycle, reporting about the processes followed to obtain the different metrics, being one of the core parts of D2.8 and D2.9.

1 Introduction

1.1 Purpose of the document

FlexiGroBots project is an Innovation Action aiming to build a platform for flexible heterogeneous multi-robot systems used for intelligent automation of precision agriculture operations, providing multiple benefits to farmers around the world. In this vision, fleets of heterogeneous robots will be able to execute complex missions in an orchestrated and coordinated way overcoming some of the main barriers that currently limit the adoption of unmanned vehicles and robotics technologies in the agriculture domain.

Three real-world pilots are part of the project to assure that the development of the FlexiGroBots platform and services addresses the requirements of the multiple stakeholders involved in the automation of precision agriculture operations based on AI and robotics technologies. An overall description of the objectives of each one of them is included in Figure 1 below.

Grapevines (Spain)

- **Early detection of Botrytis cinerea** using geolocated references from drone's images. Ground robots will be sent to confirm the presence of the disease.
- Accurate **application of phytosanitary treatment** with ground robots.
- **Autonomous transportation of grapes** through a fleet of small mobile robots that will safely follow human operators.

Rapeseeds (Finland)

- Based on the geolocated references extracted from drones and smart traps, ground robots will obtain close-range images to **identify areas with insects**.
- Fields' maps obtained by UAVs will be used to send UGVs equipped with a robotic arm in order to perform **rumex plant weeding**.
- **Silage harvesting** with ISOBUS robotised tractors.
- **Hotspot pesticide spraying** with drones and tractors.

Blueberries (Lithuania and Serbia)

- Hyperspectral data and satellite images will be analysed using AI and ML for **early-stage blueberry disease detection**.
- **Automated soil sampling** based on a modular robotic platform and considering the management zones determined from drones images and satellite data.
- **Precise and autonomous agrichemical spraying** for weeds destruction
- **Precise fertiliser application** using yield predictions from drones and satellite image.

Figure 1 Summary of FlexiGroBots pilots

They will be used also to demonstrate the positive impact and benefits of the project results, performing exhaustive validation campaigns to obtain Key Performance Indicators that will measure the success of the project and will pave the way for the subsequent commercialisation and exploitation of FlexiGroBots main assets.

The three FlexiGroBots pilots were carefully selected to represent enough level of diversity in terms of types of crops, geographical regions, weather conditions, national regulations, agricultural machinery, robots and digital platforms.

Although having such a variety supposes additional complexity with respect to functional and non-functional requirements, imposing also additional challenges to achieving the seamless integration with already existing systems, the consortium opted for this choice to maximise the scalability, replicability and flexibility of the project's results with the final goal to have a wider impact in the agricultural sector.

The goal of this document is to describe the process that has been followed during the first year of the project in order to foster the convergence between the three pilots with respect to their vision, expectations, architecture and technical building blocks that will be integrated, deployed and used in heterogeneous precision agriculture tasks involving fleets of multi robots. The document also presents an analysis of the mapping and application in the three pilots of the components that are part of the FlexiGroBots platform according to the content of deliverable D2.2[2].

The first twelve months of the project have been focused on tasks like the identification of requirements, the specification of the architecture and the pilots' use-cases, the preparation of the test sites, the acquisition of needed material and components and the implementation of initial prototypes or preliminary experiments in the field. From the very first moment of the second year of the project, the partners will begin an intense phase devoted to the integration of the FlexiGroBots platform prototype in the pilots. To address the new phase of the project with strong guarantees, a detailed plan has been defined, including some high-level objectives and also a meticulous backlog that will be pursued considering an agile approach.

Finally, the list of Key Performance Indicators (KPIs) proposed in the Description of Action (DoA) has been reviewed, selecting the appropriate ones for each one of the pilots, extending them with additional metrics resulting from the specification process and studying the validation mechanisms that will be used to assess them and to obtain the corresponding values.

1.2 Relation to other project activities

Deliverable D2.7 is the first outcome of *T2.5 - Pilot's methodology, follow-up and alignment* and the third of *WP2 - Requirements, architecture and standardization*, after the release in M9 of the project of *D2.1 - Stakeholder view to FlexiGroBots system scenarios* [1], which was devoted to describing the stakeholders' view to FlexiGroBots system scenarios. It is going to

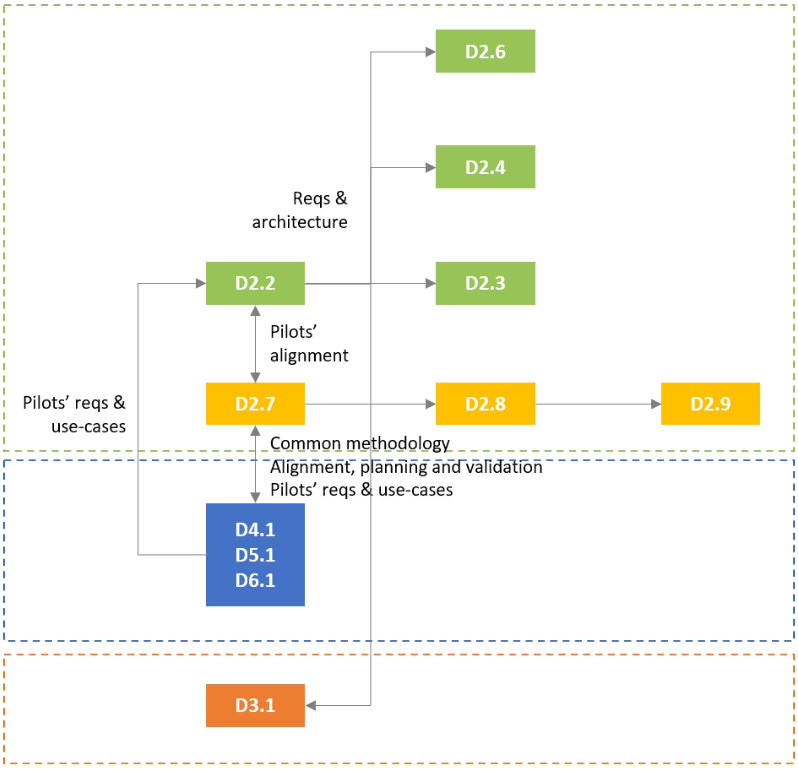

Figure 2 Deliverables linked to D2.7

be released in parallel with *D2.2 - Requirements and platform architecture specifications*, in which the main goal is to specify the project requirements and design FlexiGroBots platform architecture. The role of D2.7 has been fundamental to achieve that the three pilots provide the same type of information, applying a common methodology and following similar time plans for the preparation of *D4.1 - Pilot 1 objectives, requirements and design* [4], *D5.2- Pilot 2 objectives, requirements and design* [5] and *D6.1 - Pilot 3 objectives, requirements and design* [6]. At the same time, the work done for D2.7 will be continued under the umbrella of T2.5 to closely monitor the progress of the pilots' execution and validation until the end of the project. Two new versions of this document will be published with *D2.8 - Pilot alignment and joint assessment report 2* and *D2.9 - Pilot alignment and joint assessment report final* at M24 and M36 respectively.

1.3 Structure of the document

This document is structured in six major sections:

- **Section 1** introduces the objectives and content of this document.
- **Section 2** presents the common methodology followed to specify and prepare the three FlexiGroBots pilots.
- **Section 3** includes an analysis of the mapping of the FlexiGroBots platform and the three pilots.

- The principles of the agile methodology that will guide the pilots' execution and validation will be the main topic addressed in **Section 4**, also including the description of the backlog tasks and the timeline for the execution and validation.
- **Section 5** is focused on the assessment of the KPIs and the discussion about the validation procedures.
- Finally, **section 6** ends the document with the analysis of the obtained results, conclusions and next steps.

2 Common methodology for FlexiGroBots pilots' specification and preparation

The core objective of T2.5 during the first year of the project has been to create a common set of tools to guide the specification and preparation processes of the three project pilots, which are characterised by great diversity, and which could suppose an important risk for the project execution if their visions are not aligned and do not converge into a coherent vision that can be transferred to the design and implementation of FlexiGroBots platform. The main elements of the methodology are illustrated in Figure 3 below.

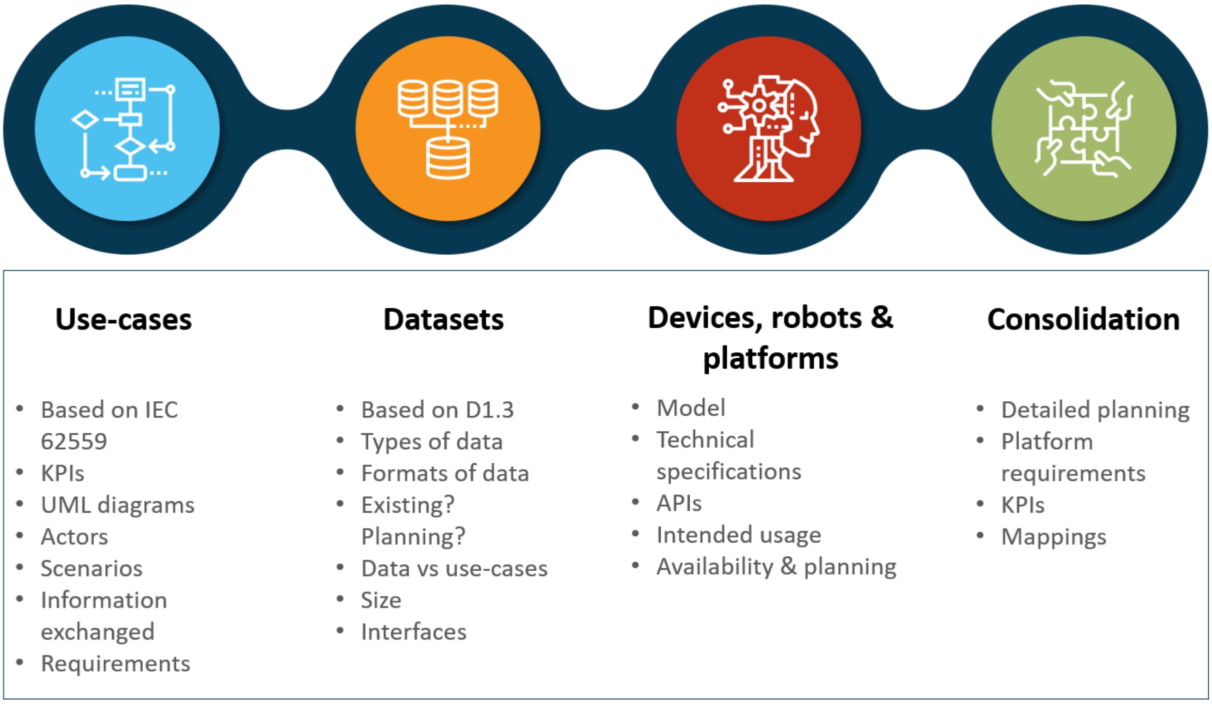

Figure 3 Common methodology for FlexiGroBots specification and preparation

2.1 Pilots' use-cases specification

The specification of the pilots' uses-cases has been done following the templates of the *IEC 62559-2:2015 Use case methodology* standard [3] in order to guarantee that all the needed aspects are covered with enough depth in the three cases and to obtain homogeneous information in the initial deliverables of WP4, WP5 and WP6.

IEC 62559-2:2015 standard defines an exhaustive but comprehensive template covering the following aspects:

- Scope and objectives for the use-case.
- Narrative including short and complete descriptions.

- UML use-case diagrams that model the functionalities used by the different actors.
- Identification of involved actors, having to provide their type, description and the group to which they belong.
- Step-by-step analysis of the scenarios that composed the use-case. For each scenario, the template requests to indicate a description, primary actor, triggering event, pre-conditions and post-conditions. Then, for each step, details about the exchanges of information must be fulfilled.
- Requirements' collection.
- Common terms and definitions.

The resulting information for this process has been included in chapter 2 of D4.1, D5.1 and D6.1, which are due to M12 (December 2021). They have served as the baseline in order to consolidate the functional and non-functional requirements that are the main content of chapter 4 of D2.2.

2.2 Description of the datasets

As part of the content of the *D1.3 Data Management Plan [7]*, a data collection questionnaire was included to document all datasets produced by the project. In the same document, it was proposed to fill the questionnaires in M06 (June 2021), M18 (June 2022) and M36 (December 2023) so that they could be included in the project's periodic reports. Nevertheless, as having access to high-quality data is a prerequisite for training many of the AI components required both for the FlexiGroBots platform and for the own pilots, T2.5 has also coordinated a continuous update of the information produced by the three pilots. In this sense, it must be highlighted that although the project is still finishing its first year, FlexiGroBots partners have achieved to generate a good number of datasets and some of them have been already published openly.

The complete information about the datasets is included in chapter 4 of D4.1, D5.1 and D6.1. With the aim to offer to the reader an overall vision of the situation at the project level, Table 1 summarizes the status so far.

Dataset	Pilot	Size	URL
Sensor and meteorology data	Spain (WP4)	N/A	Not ready yet.
Late Botrytis disease ground images (AGV)	Spain (WP4)	~3GB	http://dx.doi.org/10.20350/digitalCSIC/14011
Late Botrytis disease aerial videos (UAV)	Spain (WP4)	~7,5GB	https://doi.org/10.5281/zenodo.5654707

Dataset	Pilot	Size	URL
Drone images: RGB, multispectral, hyperspectral	Finland (WP5)	~500GB	ftp://flexigrobots.collab-cloud.eu/
Drone images: RGB close up	Finland (WP5)	~50GB	ftp://flexigrobots.collab-cloud.eu/
UGV images/video (RGB)	Finland (WP5)	~1GB	ftp://flexigrobots.collab-cloud.eu/
Tractor vision system images (RGB)	Finland (WP5)	¨1GB	ftp://flexigrobots.collab-cloud.eu/
Satellite images	Finland (WP5)	~100GB	ftp://flexigrobots.collab-cloud.eu/
Application tasks: machinery inputs, navigation routes	Finland (WP5)	~100MB	ftp://flexigrobots.collab-cloud.eu/
Orthomosaics	Finland (WP5)	~50GB	ftp://flexigrobots.collab-cloud.eu/
UAV images of blueberries in Serbia	Serbia (WP6)	~24GB	https://zenodo.org/record/5712792#.YZtTUOTTUWM
UAV images of blueberries in Lithuania	Lithuania (WP6)	~600GB	http://gofile.me/5G1pV/pbaq96qc5

Table 1 Summary of datasets generated by the pilots in M12

2.3 Description of devices, robots and platforms

A complete view of the devices, robots and digital platforms included in each one of the pilots is going to be included. For all these elements the following information has been requested:

- Explain if an already available commercial product is going to be used. This point must indicate if an improvement or a new development is planned.
- Technical specifications and functionalities are provided by each component.

- Interfaces and Application Programming Interfaces (APIs) in order to exchange data and/or to control commands, including descriptions of the information or data models.
- Intended usage as part of the pilots' use-cases.
- Availability and planning for the acquisition, development and deployment.

All these aspects are included in chapter 5 of D4.1, D5.1 and D6.1.

The following Table 2 summarises the information collected in M12 of the project.

Device, robot or platform	Pilot	Type	Commercial, improvement or new product	Availability
Motes and weather stations	Spain (WP4)	Device	Commercial	Yes
DJI Matrice 210 RTK	Spain (WP4)	UAV	Commercial	Yes
DJI Matrice 300 RTK	Spain (WP4)	UAV	Commercial	Yes
Adapted Renault Twizy	Spain (WP4)	UGV	Improvement	Yes
Adapted RB-VOGUI	Spain (WP4)	UGV	Improvement	Yes
Cultiva Decisiones DSS	Spain (WP4)	Digital platform	Improvement	Yes
Robot Tractor	Finland (WP5)	Machinery	Improvement	Yes
VPZ sprayer	Finland (WP5)	Machinery	Commercial	Yes
Probot UGV	Finland (WP5)	UGV	New product	Summer 2022
LUKE UGV	Finland (WP5)	UGV	Improvement	Yes
Robot arm (weeding tool)	Finland (WP5)	UGV	Improvement	Yes
DJI Phantom 4 RTK	Finland (WP5)	UAV	Commercial	Yes
DJI Phantom 4 Multispectral	Finland (WP5)	UAV	Commercial	Yes
DJI Mavic Zoom 2	Finland (WP5)	UAV	Commercial	Yes
FreeFly Alta X	Finland (WP5)	UAV	Commercial	Yes
DJI Agras T-16	Finland (WP5)	UAV	Commercial	Yes
MyFarm FMS	Finland (WP5)	Digital platform	Improvement	Yes

Device, robot or platform	Pilot	Type	Commercial, improvement or new product	Availability
Plant-O-Meter	Serbia (WP6)	Device	Improvement	Yes
UGV Soil Sampling	Serbia (WP6)	UGV	New product	Yes
DJI P4 Multispectral	Serbia (WP6)	UAV	Commercial	Yes
VTOL Quantum Trinity F90+	Serbia (WP6)	UAV	Commercial	Yes
DJI Matrice 600 Pro UAV	Lithuania (WP6)	UAV	Commercial	Yes
AgroSense FMIS	Serbia (WP6)	Digital platform	Improvement	Yes
Agrosmart	Lithuania (WP6)	Digital platform	Improvement	Yes

Table 2 Summary of devices, robots and platforms to be used by the pilots

2.4 Consolidation

The final objective of T2.5 has been to collect, analyse, harmonize and consolidate all the information received from the three pilots, which has been used as input to refine the use-cases, to convey to a specification of FlexiGroBots platform that is transversal to all of them and has been included in D2.2 and to plan the next activities for the execution of the tests and the validation of the project components. The next sections of this document provide further details about the results of the consolidation process.

3 Alignment between FlexiGroBots platform and pilots

3.1 Pilot 1 – Grapevines

3.1.1 AI platform

FlexiGroBots AI platform will support data scientists and ML engineers participating in the pilot during the complete lifecycle of the models for the detection of Botrytis both in images collected by drones and ground robots. The platform will offer services to facilitate experimentation and development in Python language and will give access seamlessly to powerful hardware infrastructure. The platform will enable the deployment of the models over the most common cloud platforms or on-premises servers through the adoption of Docker containers and Kubernetes. Since the models may be embedded directly in the robots, for lightweight frameworks. AutoML functionalities will reduce the time and effort needed to create the most accurate models.

3.1.2 Common data enablers and services

The grapevine pilot has four main business entities that leverage the concepts of the agricultural data space provided as a service by the FlexiGroBots platform operator to exchange sensitive data in a sovereign way, allowing the farmer to define the way the different data sets will be used from the rest of the pilot entities.

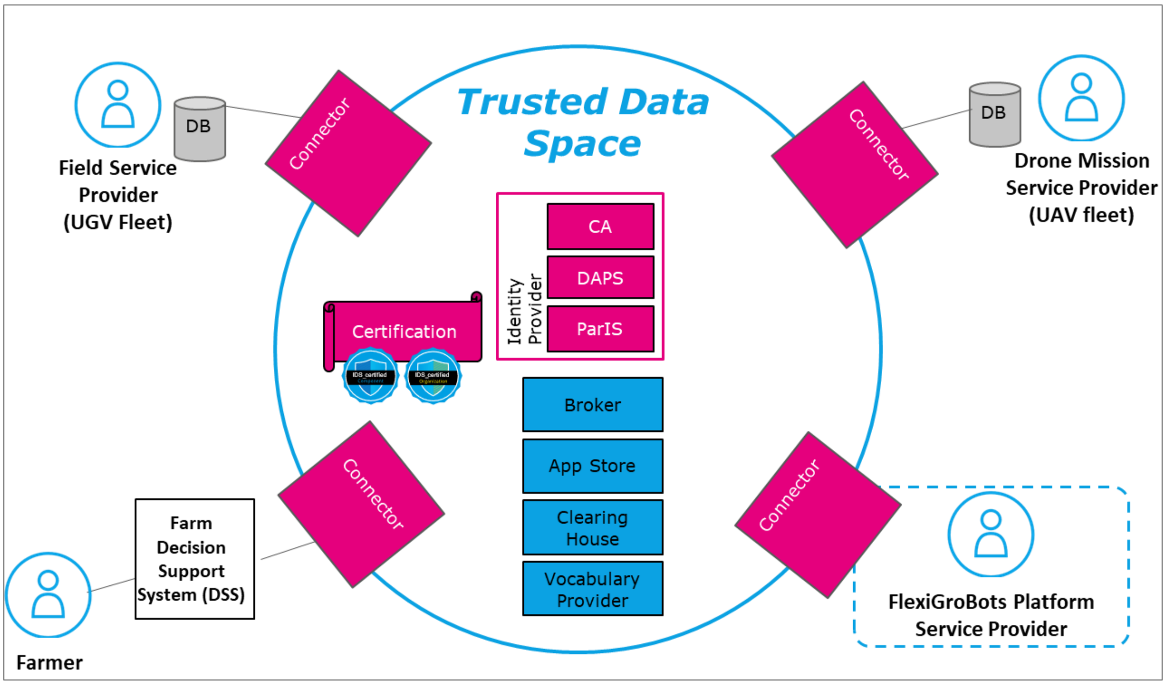

Figure 4 Depiction of the embryonic Agriculture Data Space in Pilot 1

The four entities where connectors will be installed for IDSA-based secure and standardized data exchange are the farm and its Decision Support System (DSS), the Field Service Provider (UGV Fleet), the Drone Mission Service Provider (UAV fleet) and the FlexiGroBots AI platform Provider. The high-level overview of the instantiation of the Data Space for pilot 1 is shown in Figure 4. The detailed description of the different infrastructure components and their role is described in deliverable “D2.2 Requirements and platform architecture specifications”.

3.1.3 Geospatial enablers and services

FlexiGroBots geospatial enablers and services, which are compliant with OGC standards, will allow obtaining and storing raster information coming from satellites, UAVs or robots. Also, to perform geospatial queries. The information will contain images, ground control points, ground truth data, etc.

3.1.4 Common application services

Images generated by aerial robots during exploratory missions will be used to generate high-resolution images, NVDIs and initial identification of problematic areas using one of the common application services, the orthoimage assessment tool. Then, specific models will be generated with the FlexiGroBots AI platform in order to obtain the list of areas that must be explored by ground robots for being potentially affected by the Botrytis.

3.1.5 Mission Control Centre

As it is widely explained in D4.1, the operators of the ground robots will rely on the Mission Control Centre, through the Robot Fleets Management Systems (RFMS) connected to the DSS platform, to plan, execute and supervise the exploratory tasks to confirm the presence of Botrytis in the problematic waypoints resulting from the analysis and processing of the aerial images. At the same time, it will serve the same purpose during the application of phytosanitary treatments and assisted harvesting missions. Therefore, during the pilot specification, it has been confirmed the need to have the different functionalities initially proposed for the MCC: mission planner, mission supervisor, fault recovery module, alarm notification manager and adaptive mission planning. This component will have a key role in planning the execution of complex agricultural tasks, monitoring the correct behaviour of the different ground and aerial robots' fleets and raising alarms when faults are generated.

3.2 Pilot 2 – Rapeseeds

3.2.1 AI platform

As in the case of the first pilot, the training of the ML models for the detections of pests and rumex plants considering images collected by drones and aerial robots will be done thanks to the AI platform. Also, common application services used in the pilot for situation or context awareness will be developed thanks to these functionalities, e.g., real-time detection of moving objects, detection and prediction of hazard situations. The models will be optimized to perform the inferencing in constrained hardware platforms that are typical in robotics systems. They will be also offered following an "as a service" paradigm to ease access to powerful AI functionalities. Thanks to the common data enablers and services, the AI platform will automatically ingest data from the different devices and systems.

3.2.2 Common data enablers and services

The rapeseeds-pilot is built on top of the agriculture data space concept that is provided as a service by the FlexiGroBots platform provider. The pilot has four business entities the farm, drone mission service provider, field service provider, and FlexiGroBots platform service provider. The farm entity divides into three cloud services that are the farm management system, farm data storage system, and IoT platform solution. All these systems manage data owned by the farmer.

All six entities have IDSA connectors as interfaces between their data management solutions and data spaces. The communication of confidential data such as farm tasks, task reports, photos, and analyses results are done using IDSA communication.

Below, an overview of the way Pilot 2 uses the data space components. A detailed description of the different infrastructure components and their role is described in deliverable “D2.2 Requirements and platform architecture specifications”.

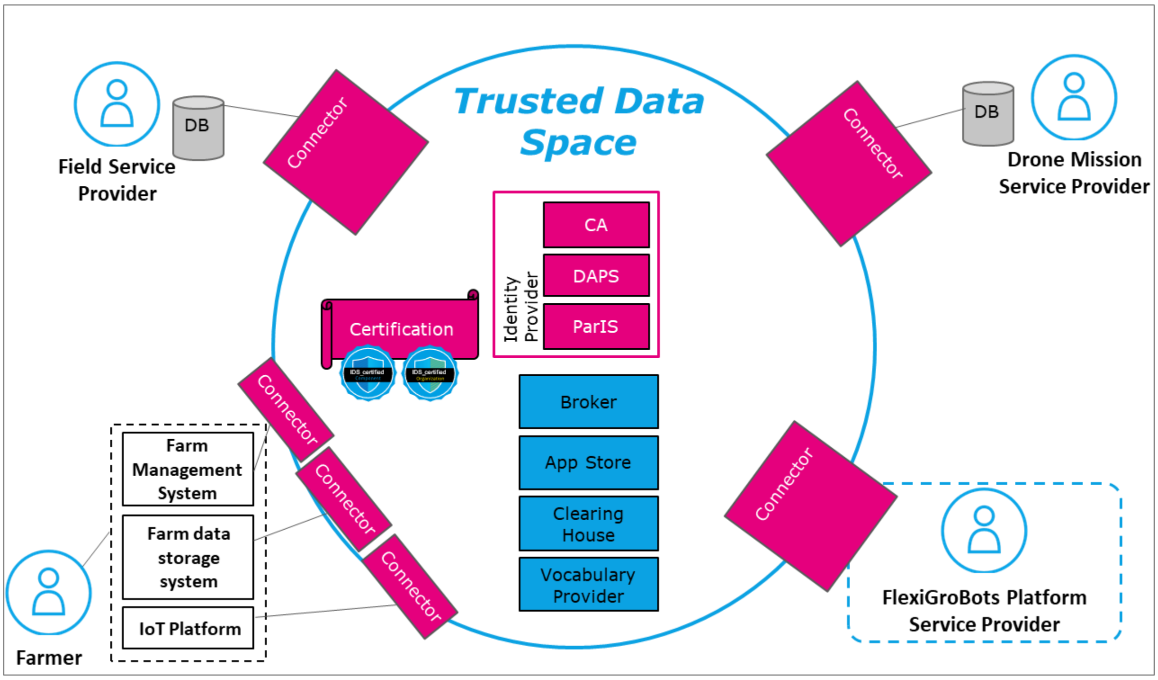

Figure 5 Depiction of the embryonic Agriculture Data Space in Pilot 2

3.2.3 Geospatial enablers and services

These functionalities will be part of pilot 2. It is not defined yet whether required geospatial functionalities will be implemented using the FlexiGroBots service or maps provided by the pilot’s farm management system. Depending on the final decision, the list of requirements collected in D2.2 will be updated in D2.3.

3.2.4 Common application services

Rapeseeds-pilot consists of three main use cases: Rapeseed pest management, silage harvesting and Rumex weeding. In all of these use cases of the pilot, the AI services provided by the FlexiGroBots platform are used.

- In rapeseed pest management, the detection of pests from the drone photos taken by the drone service provider is done using the pest detection service of the platform.
- In silage harvesting use case, the situation awareness service monitoring the safety of the tractor fleet operations relies on object detection services of the platform.
- In Rumex weeding, the detection of the locations of Rumex from drone images is done using the detection service of the platform.

3.2.5 Mission Control Centre

Rapeseed pilot has multi-robot operations in all use cases.

- In pest management and rumex weeding use cases, the robot operations are sequential. First, a survey mission is done, and the second step is spraying either with a drone or a UGV or weeding with a UGV. Between these missions, there are analysis, decision, and mission planning phases. In the case of large fields, these missions could benefit from parallel execution with multiple robots, but that has not been planned in the pilot.
- Silage harvesting use case consists of harvesting timing planning that involves drone/UGV mission and the actual harvesting where a tractor fleet is operating on the field. There are three main tasks: cutting, raking, and collecting silage that is done with a mower, a wind rower, and a loader tractor. The pilot plan is to make the wind rover an autonomous robot. Simultaneously with harvesting the plan is to have a surveillance drone hovering on top of autonomous tractors and streaming video to the situation awareness service. The surveillance drone control will be based on wind rower position. This could be based on the multi-robot control service of the platform.

3.3 Pilot 3 – Blueberries

3.3.1 AI platform

The first task in the pilot is image analysis. UAVs will fly over blueberries and based on the detected weeds and plant diseases, the UGV will be sent to target-spray the problematic areas. However, these areas first need to be recognised, which means that the UAV images need to be "segmented". This will be done using deep learning and image recognition algorithms trained on the platform. To enable user-friendly model training and running, even for non-professionals in AI (agronomists, biologists and geoscientists), the platform's AutoML functionality will be essential for this use-case. AI and image processing algorithms will be also used for management zone delineation, where the centroids will signify locations where the UGV should perform soil analysis. AI models trained on the data from Pilot 3 will be made available to other pilots as well, as model transfer might yield higher accuracy of the deep learning algorithms.

3.3.2 Common data enablers and services

For the sovereign exchange of data between different business entities, the pilot will use the IDSA principles. Datasets generated by the UAVs will be placed in a virtual container along with the corresponding metadata that describes the location, time of scanning, UAV and camera used, image resolution and other details. Similar holds for other data generated within the pilot (soil analyses, sensory data and soil electromagnetic scans). The containerised datasets will be integrated into the platform using IDSA connectors, giving the owner of the data (farmer) the opportunity to define policies about how the datasets will be used from the Flexigrobots Platform Provider. The use of IDSA connectors will also enable sharing of the data between the pilots as well as with external companies. The three different business entities that have IDSA connectors as interfaces between their data management solutions are depicted below. A detailed description of the different infrastructure components and their role is described in deliverable "D2.2 Requirements and platform architecture specifications".

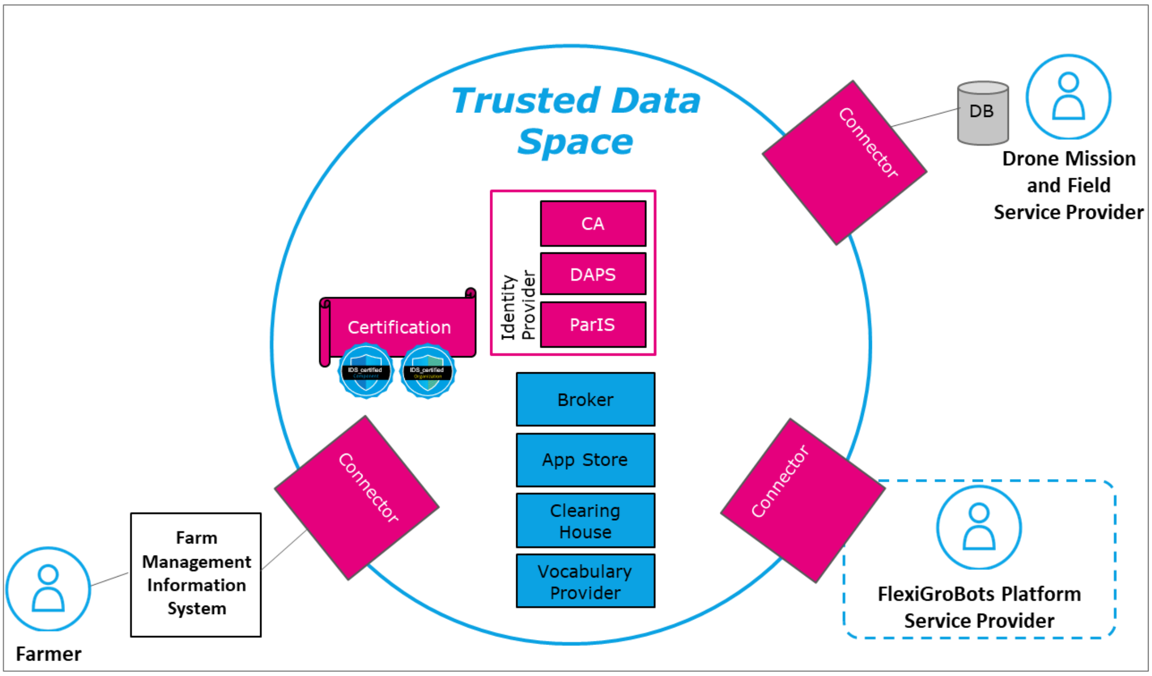

Figure 6 Depiction of the embryonic Agriculture Data Space in Pilot 3

3.3.3 Geospatial enablers and services

Spatial data is essential for the successful development and implementation of technology in Pilot 3. Georeferenced UAV images are the basis of disease/weeds mapping and determination of soil sampling locations and geospatial, but other layers of information will be analysed as well, namely satellite images and soil electrical conductivity maps. Satellite images have a much lower spatial resolution (10m compared to ~3 cm) but are much more scalable than UAVs. Although several blueberry rows fit into a single satellite pixel, the applicability of satellite image processing in blueberry monitoring will be explored during the course of the project. All geospatial layers will follow OGC standards in order to successfully form a *data cube*.

3.3.4 Common application services

A number of services are similar or identical throughout the use-cases, namely image processing related algorithms. These algorithms generally perform image segmentation and object recognition. In Pilot 3, it is the diseased areas and weeds that need to be recognised, while in the others the fruits, humans or other types of objects are recognized. However, the very same (or similar) deep learning architecture might yield the best results in all three pilots and thus this component should be shared reused.

3.3.5 Mission Control Centre

In order to develop and execute a particular mission, Pilot 3 will rely on this platform component. It will be used for setting up the pipeline for the UAV and UGV (i.e., scanning and action). Once the problematic areas and soil sampling locations have been defined, the Mission Control Centre will be used for route planning and navigation of the UGV through the blueberry rows.

4 Detailed planning of FlexiGroBots pilots

From the M13, the project will embrace an agile approach for the development of the different components. For each component of the FlexiGroBots platform and for the three pilots, a detailed backlog of tasks has been generated, considering the effort needed to complete them and the level of priority. Sprints of one month of duration will be considered, selecting at the beginning from the backlogs the tasks with a higher priority. At the end of each sprint, all the work package leaders will review together the results of the sprint (retrospective meeting).

In this chapter, the backlog of tasks is described for each one of the pilots. Then, high-level planning is included. The implementation of the product backlog items will drive the realisation of the use-cases specified in detail in D4.1, D5.1 and D6.1.

4.1 Pilot 1 – Grapevines

4.1.1 Product backlog

User story ID	User story	Priority	Story points
US_01_01	Creation of an IDSA connector for the DSS	High	1
US_01_02	Labelling of aerial images and aerial videos of the first field testing slot.	High	1
US_01_03	Labelling of ground images of the first field testing slot.	High	1
US_01_04	Design of DSS web apps screens.	Low	1
US_01_05	UGV Telemetry shipments implementation.	Medium	1
US_01_06	First telemetry processing on DSS Platform.	Low	3
US_01_07	Integration of DSS with Mission Control Centre	Medium	4
US_01_08	First studies of the correlation of variables in datasets for detection of Botrytis for remote sensing	High	3
US_01_09	First studies of the correlation of variables in datasets for detection of Botrytis for proximal sensing	High	3

User story ID	User story	Priority	Story points
US_01_10	Definition of the botrytis detection algorithm for remote sensing	High	5
US_01_11	Definition of the Botrytis detection algorithm for proximal sensing (real-time)	High	5
US_01_12	Web app shows telemetry data	Low	5
US_01_13	Implementation of the Botrytis detection algorithm for remote sensing	High	6
US_01_14	Implementation of the Botrytis detection algorithm for proximal sensing	High	8
US_01_15	Design and development of the Botrytis treatment equipment (UGV)	High	5
US_01_16	Integration of aerial Botrytis detection algorithm in DSS web platform.	Medium	4
US_01_17	Integration of the ground Botrytis detection algorithm in the UGV.	Medium	3
US_01_18	Integration of the treatment equipment in the UGV and crop tests.	Medium	5
US_01_19	Connection of real-time detection and Botrytis treatment. Crop tests.	Low	8
US_01_20	2nd phase of drone flights to detect Botrytis in Terras Gauda plots.	Medium	3
US_01_21	1st phase of ground inspection (UGV) to detect Botrytis in Terras Gauda plots	Low	8
US_01_22	Testing of the assistance robots during harvest. Testing continuous weighed and communications with the winery.	High	3
US_01_23	Testing of the assistance robots during harvest. Testing autonomous navigation behaviour.	Low	8

Table 3 Product backlog for pilot 1

4.1.2 Release plan

Timeline	Goals
Q1 2022	IDSA connector implementation.

Timeline	Goals
	Usage of AI platform with pilot's datasets. First studies of the correlation of variables in datasets for detection (remote and proximal sensing) of Botrytis Definition of the botrytis detection (remote and proximal sensing) algorithms.
Q2 2022	1st phase of ground inspection (UGV) to detect Botrytis in Terras Gauda plots. Definition of the botrytis detection algorithms for remote and proximal sensing respectively. Implementation of the aerial Botrytis detection algorithm using the AI platform. Implementation of the ground Botrytis detection algorithm. Visualisation of telemetry data in DSS web app.
Q3 2022	Integration UGVs and UAVs to the MCC through the Robot Fleets Management Systems (RFMS) connected to the DSS platform. DSS web platform stable implementation. 2nd phase of drone flights to detect Botrytis in Terras Gauda plots. 2nd phase of harvesting field tests in Terras Gauda plots. The first prototype of the treatment equipment, integrated with the UGV First Steps of *D4.2 Technical report on the demonstrator-specific components (CSIC, R, PU, M27).*
Q4 2022	DSS web platform tests. Labelling of images and videos (UAVs and UGVs) of the second field test slot. 2nd datasets analysis tests. Initial version of aerial Botrytis detection algorithm integrated into DSS web platform. Botrytis detection (remote and proximal sensing) algorithms validation. First version of *D4.2 Technical report on the demonstrator-specific components (CSIC, R, PU, M27).*

Table 4 Release plan for pilot 1

4.2 Pilot 2 – Rapeseeds

4.2.1 Product backlog

User story ID	User story	Priority	Story points
US_02_01	Vision system for the tractor is developed.	Medium	5
US_02_02	The robotized tractor drives a complete field mission without machinery.	High	8

User story ID	User story	Priority	Story points
US_02_03	The suitable application task is developed by using project specific tools. This will be done for the spraying drone and for the ISOBUS-sprayer.	Low	5
US_02_04	The complete mission flow is demonstrated with a spraying application.	Low	5
US_02_05	Data according to best practices will be collected above the windrower missions	Medium	1
US_02_06	Testing of separate components for situation awareness service	High	5
US_02_07	The algorithms for the rumex cluster detection based on orthophotos will be developed.	Medium	5
US_02_08	General classification methodologies and data collections for grass fields and rapeseeds	Medium	3
US_02_09	Data collection for pest detection	High	3
US_02_10	Methodologies for image capture mission	Low	5
US_02_11	Control and communication of weeding UGV	High	5
US_02_12	Rumex weeding tests and demonstration, first iteration	Medium	5
US_02_13	Digestibility data collection	Low	3
US_02_14	Digestibility and yield classification methodology developed	Medium	8

Table 5 Product backlog for pilot 2

4.2.2 Release plan

Timeline	Goals
Q1 2022	Vision system functioning, The Zed 2 – AI stereo camera-based imaging system will detect solid or moving objects in front of the robotized tractor, the first iteration. Preparation of digestibility datasets available for the project. The algorithms for the rumex cluster detection based on orthophotos will be developed. Weeding UGV construction continues.
Q2 2022	General grass and rapeseed field classification algorithms for anomaly-detections will be developed.

Timeline	Goals
	Additional dataset collection for all of the use cases will be done. Weeding robot platform ready.
Q3 2022	Additional dataset collection for all of the use cases will be done. The robotized tractor drives a complete field mission (without machinery). Data according to best practices will be collected above the windrower missions. General rapeseed field classification algorithms for anomaly-detections and flowering states will be developed. Weeding robot navigation, weed detection and communication.
Q4 2022	The situation awareness solution is demonstrated. Verify the best parameters for the pest imaging. First version of *D5.2 Technical report on the demonstrator-specific components (PRO, R, PU, M27).*

Table 6 Release plan for pilot 2

4.3 Pilot 3 – Blueberries

4.3.1 Product backlog

User story ID	User story	Priority	Story points
US_03_01	Zone delineation algorithm developed for determining soil sampling points	Medium	2
US_03_02	Robotic arm for soil sampling upgraded	High	5
US_03_03	Image segmentation algorithm prototype developed for blueberries	High	8
US_03_04	Field testing of soil sampling module	Medium	3
US_03_05	Database of UAV images from Serbia acquired	Low	3
US_03_06	Database of UAV images from Lithuania acquired	Low	3
US_03_07	Robotic sprayer arm developed	High	8
US_03_08	Integration with Mission Control Centre	Medium	5
US_03_09	Further image processing algorithms training with newly acquired data	Medium	2
US_03_10	Robotic sprayer arm integration with UGV	Medium	5
US_03_11	Field testing of robotic sprayer	Medium	3

User story ID	User story	Priority	Story points
US_03_12	Integration with IDSA	Medium	5

Table 7 Product backlog for pilot 3

4.3.2 Release plan

Timeline	Goals
Q1 2022	Initial development of image recognition system for blueberry diseases/weeds. Formation of the pipeline and achieving initial results. Development of the robotic sprayer prototype. Robotic arm for target spraying of weeds and diseased leaves.
Q2 2022	Data acquisition in Serbia (April - June). Acquisition of UAV imagery for model training; lab analysis of soil and leaves. Data acquisition in Lithuania (May - July). Acquisition of UAV imagery for model training; lab analysis of soil and leaves.
Q3 2022	Upgrade of image recognition system. Further development of advanced image recognition algorithms.
Q4 2022	UGV components prototype upgrade. Upgrading soil sampler / robotic sprayer according to the field test takeaways. First version of *D6.2 Technical report on the demonstrator-specific components (BIO, R, PU, M27).*

Table 8 Release plan for pilot 3

5 FlexiGroBots validation and Key Performance Indicators (KPIs)

Section 5 is devoted to a detailed analysis of the validation mechanisms that will be applied in each one of the pilots to evaluate the corresponding KPIs proposed in the Description of Action (see Annex 1). Some additional indicators have been added in light of the more accurate specification of the use-cases. At the end of the section, a matrix is included to show which KPIs are addressed by each pilot.

5.1 Pilot 1 – Grapevines

KPI ID	Description	Validation mechanism	Success criteria
KPI3	Demonstrators using more than 90% of the MCC services	The list of MCC services used within the pilot compared to the total list.	= 1
KPI6	Number of data sets shared within the pilots	Pilot 1 shares datasets on Zenodo and other public repositories.	>= 4
KPI7	Number of pilots using georeferenced agriculture-related data analytics	Pilot 1 uses georeferenced agriculture-related data, for instance, image segmentation.	= 1
KPI8	Number of datasets shared with third parties via ADS	Datasets are accessible to external entities to the project through FlexiGroBots IDSA compliant ADS.	>= 2
KPI9	Number of novel agricultural AI methods or Machine Learning (ML) models	Botrytis detection uses ML models both by remote sensing and proximal sensing.	>= 2
KPI10	Number of potential new products and services based on those new AI methods / ML models	Pilot 1 develops products to detect Botrytis with image segmentation and robotics-assisted harvesting.	>= 2
KPI12	Pilots for Assessment List of the Ethics Guidelines for Trustworthy AI	Assessment List of the Ethics Guidelines for Trustworthy AI is completed for pilot 1. Design, implementation and	= 1

KPI ID	Description	Validation mechanism	Success criteria
		execution following the guidelines.	
KPI14	Platform assessment (cross-pilot)	FlexiGroBots platform used and assessed in pilot 1	= 1
KPI15	Demonstrators incorporating both UAV and UGV robotic platforms	Use UAV to generate the risk map and UGV to corroborate and apply the pesticide	= 1
KPI16	Number of robots taking part in demonstrated multi-robot systems	Multiple UAVs for different dataset acquisition and one UGV for ground validation	>= 2
KPI17	Number of DIHs with the capability of demonstrating FlexiGroBots pilots the project ends	Technologies involved in the use-cases are shared with DIHs. Material to support demonstrations is prepared: trainings, technology demonstrators, etc.	>=1
KPI18	Number of real-world pilots	Pilots are executed in the fields with conditions similar to production scenarios.	= 1
KPI19	Numbers of regions where the FlexiGroBots demonstrators are deployed and run	Pilot conducted in Spain	= 1
KPI21	Demonstrators showing AI4EU marketplace use cases	Pilot's demonstrators will integrate components published in the AI4EU marketplace.	= 1
KPI22	Number of agricultural Machine Learning (ML) models contributed to the AI4EU marketplace	Botrytis detection and generation of risk map, and harvest aid	= 3
KPI26	Number of DIHs actively engaged in pilots' development and demonstrations	AIR4S and Robocity2030	= 2
KPI28	Average percentage of improvement in the performance of tasks by robots	Time to execute the tasks will be measured prior to the adoption of FlexiGroBots technologies. Measurements will be repeated at the end of the project.	> = 25%

KPI ID	Description	Validation mechanism	Success criteria
KPI29	Cost savings per season (Botrytis detection, phytosanitary treatments, transport)	Costs will be measured prior to the adoption of FlexiGroBots technologies. Measurements will be repeated at the end of the project.	>= 20%
KPI32	Number of different tasks robots are able to carry out	Botrytis detection, treatment application, harvest support.	>= 3
KPI33	Number of new different services offered to farmers	Botrytis detection, treatment application, harvest support.	>= 3
KPI34	Single pilot duration	Time of single autonomous robot operation in the demonstration.	>= 1 hour
KPI37	Number of components compatible with IDSA and OGC standards implemented and/or integrated within the system	Botrytis detection and pesticide application use georeferenced information following the OGC standard, while the ingestion of UAV/UGV data relies on the IDSA standard.	>= 5
KPI38	Reduce the use of the phytosanitary product, minimize costs and environmental damages	Use within pilot / regular use	>= 20%
KPI39	Reduce the cost of grape transport	Comparing production costs (staff costs, fuel costs…) between one of the plots used in the pilot and one of the other plots on the farm. These two plots should have a similar surface, slope, and distance to the winery.	Baseline: 220€/h per season Improv: 11% Target: 195 €/ha per season.
KPI40	Reduce time of grape transport	Comparing the time costs between one of the plots used in the pilot and one of the other plots on the farm, within a defined period. These two plots should have a similar surface, slope, and distance to the winery.	Baseline: 180 min Improv: 50% Target: 90 min

KPI ID	Description	Validation mechanism	Success criteria
KPI43	Reduction of pesticide usage	Comparing expenditure on plant protection products between one of the plots used in the pilot and one of the other plots on the farm. A representative sample of an equal number of plants must be taken for both plots.	Baseline: 155€/h per season Improv: 9% Target: 141 €/ha per season
KPI48	Reduce inspection costs	Visual validation. Within a representative sample of plants, comparing between operator detection and algorithm prediction. Comparing yield loss between one of the plots used in the pilot and one of the other plots on the farm. These two plots should have similar surface and slope.	Baseline: 86€/ha. Improv: 30% Target: 59,5 €/ha

Table 9 Validation of relevant KPIs for pilot 1

5.2 Pilot 2 – Rapeseeds

KPI ID	Description	Validation mechanism	Success criteria
KPI3	Demonstrators using more than 90% of the MCC services	The list of MCC services used within the pilot compared to the total list.t	= 1
KPI6	Number of data sets shared within the pilots	Data sets shared as open research data from pilot 2. Number of data sets with DOI.	>=2
KPI7	Number of pilots using georeferenced agriculture-related data analytics	Pilot 2 uses georeferenced image segmentation.	= 1
KPI8	Number of datasets shared with third parties via ADS	Datasets are accessible to external entities to the project through FlexiGroBots IDSA compliant ADS.	>= 2

KPI ID	Description	Validation mechanism	Success criteria
KPI9	Number of novel agricultural AI methods or Machine Learning (ML) models	Publication of the ML models in FlexiGroBots AI platform.	>= 3
KPI10	Number of potential new products and services based on those new AI methods / ML models	Silage harvesting, pests' management, rumex weeding.	>= 2
KPI12	Pilots for Assessment List of the Ethics Guidelines for Trustworthy AI	Assessment List of the Ethics Guidelines for Trustworthy AI is completed for pilot 2. Design, implementation and execution following the guidelines.	= 1
KPI14	Platform assessment (cross-pilot)	FlexiGroBots platform used and assessed in pilot 2	= 1
KPI15	Demonstrators incorporating both UAV and UGV robotic platforms	Number of final demonstrations in pilot 2 where UAVs or UGVs are involved.	= 1
KPI16	Number of robots taking part in demonstrated multi-robot systems	Aerial and ground robots worked together in robotics missions.	>= 4
KPI17	Number of DIHs with the capability of demonstrating FlexiGroBots pilots the project ends	Technologies involved in the use-cases are shared with DIHs. Material to support demonstrations is prepared: trainings, technology demonstrators, etc.	= 1
KPI18	Number of real-world pilots	Pilots are executed in the fields with conditions similar to production scenarios.	= 1
KPI19	Numbers of regions where the FlexiGroBots demonstrators are deployed and run	FlexiGroBots results are demonstrated in conditions similar to production scenarios and involving local stakeholders.	= 1
KPI21	Demonstrators showing AI4EU marketplace use cases	Pilot's demonstrators will integrate components published in the AI4EU marketplace.	= 1

KPI ID	Description	Validation mechanism	Success criteria
KPI22	Number of agricultural Machine Learning (ML) models contributed to the AI4EU marketplace	Number of methods used in pilot 2 demonstrations that are distributed via AI4EU	>=3
KPI28	Average percentage of improvement in the performance of tasks by robots	Time to execute tasks within the pilot will be measured prior to the usage of FlexiGroBots technologies. The time will be measured again at the end of the pilot.	<= 50%
KPI32	Number of different tasks robots are able to carry out	For instance: rumex identification, rumex removal, rumex transportation, pests' detection, pest's spraying. survey missions.	>= 5
KPI33	Number of new different services offered to farmers	For instance: harvesting planning, situation monitoring, pests' management, rumex weeding.	>= 6
KPI34	Single pilot duration	Time of single autonomous robot operation in the demonstration.	>= 30 minutes
KPI37	Number of components compatible with IDSA and OGC standards implemented and/or integrated within the system	Components' prototypes are used in the pilot through dedicated deployments or called following "as a service" paradigm.	>= 5
KPI42	Autonomous tractor operation	Autonomous operation validated in demonstration activity	= 1
KPI43	Reduction of pesticide usage	The applied pesticide amount compared to normal use.	<= 75%
KPI48	Work efficiency. The utilization of robot tractors in silage fleet shall decrease the need for human labour when the robotized tractor supervisor can	Work effort needed per autonomous tractor in autonomous harvesting task compared to traditional harvesting task.	<= 50% per added simultaneously operating working unit.

KPI ID	Description	Validation mechanism	Success criteria
	simultaneously operate another working unit.		
KPI49	Decrease environmental load saving pesticides	Area of the field sprayed vs. area of the whole field.	<= 75%
KPI50	Increased safety. Robotics together with an External situation monitoring system has the capability to create a more comprehensive view of the situation	The ratio of detected hazard situations vs. combined robot detected hazard situations.	>= 1
KPI51	Rumex mapping. The existence of Rumex-weeds enables targeted weeding operations thus decreasing manual labour needs	The amount of detected Rumex spots vs. the amount of Rumex spots detected by manual operation.	>= 80%
KPI52	Less laborious manual work for pests mapping	Automated identification time compared to the estimated time taken by manual detection. (mapping flight time + setting up the drone system vs. walking time through the mapped area).	<= 50%
KPI53	Identification comparison to manual detection of pests.	Number of detected pest invasion areas compared to manually detected pests.	>= 90%
KPI54	The harvesting timing can be improved thus providing more digestible dry matter.	Mathematical estimate of yield increase with changed harvesting order.	>= 1 % more digestible dry matter from selected fields
KPI55	Weeding efficiency	Ratio of weeded Rumex and manually detected Rumex.	>= 50%

Table 10 Validation of relevant KPIs for pilot 2

5.3 Pilot 3 – Blueberries

KPI ID	Description	Validation mechanism	Success criteria
KPI3	Demonstrators using more than 90% of the MCC services	The list of MCC services used within the pilot compared to the total list	= 1
KPI6	Number of data sets shared within the pilots	Pilot 3 datasets shared on Zenodo or other public repositories.	>= 2
KPI7	Number of pilots using georeferenced agriculture-related data analytics	Pilot 3 using georeferenced image segmentation	>= 2
KPI8	Number of datasets shared with third parties via ADS	Datasets are accessible to external entities to the project through FlexiGroBots IDSA compliant ADS.	>=2
KPI9	Number of novel agricultural AI methods or Machine Learning (ML) models	Blueberry plant detection and weed/disease detection algorithms developed. Publication of the ML models in FlexiGroBots AI platform.	>= 2
KPI10	Number of potential new products and services based on those new AI methods / ML models	Weeds and diseases monitoring and detection, smart soil sampling, precision spraying.	>= 2
KPI12	Pilots for Assessment List of the Ethics Guidelines for Trustworthy AI	Assessment List of the Ethics Guidelines for Trustworthy AI is completed for pilot 3. Design, implementation and execution following the guidelines.	= 1
KPI14	Platform assessment (cross-pilot)	FlexiGroBots platform used in pilot 3	= 1
KPI15	Demonstrators incorporating both UAV and UGV robotic platforms	Number of final demonstrations in pilot 2 where UAVs or UGVs are involved. For instance,	= 1

KPI ID	Description	Validation mechanism	Success criteria
		using UAVs for mapping and UGV for actions	
KPI16	Number of robots taking part in demonstrated multi-robot systems	Aerial and ground robots worked together in robotics missions.	>= 2
KPI17	Number of DIHs with the capability of demonstrating FlexiGroBots pilots the project ends	Robotics DIH Belgrade, Agri-Food DIH BioSense	>= 2
KPI18	Number of real-world pilots	At least one field is analysed in Serbia and another in Lithuania. Pilots are executed in the fields with conditions similar to production scenarios.	2
KPI19	Numbers of regions where the FlexiGroBots demonstrators are deployed and run	Pilots conducted in Serbia and Lithuania	= 2
KPI20	Number of demonstrators deployed and running in different regions	The same technology working successfully in both Serbia and Lithuania	= 1
KPI21	Demonstrators showing AI4EU marketplace use cases	Blueberry data and algorithms shared through the AI4EU framework	= 2
KPI22	Number of agricultural Machine Learning (ML) models contributed to the AI4EU marketplace	Blueberry plant detection and weed/disease detection algorithms present at AI4EU	>=2
KPI26	Number of DIHs actively engaged in pilots' development and demonstrations	Robotics DIH Belgrade, Agri-Food DIH BioSense	= 3
KPI28	Average percentage of improvement in the performance of tasks by robots	Soil sampling time sped up. Pesticide amount reduced. Baseline will be measured prior to the adoption of FlexiGroBots technologies.	> = 25%

KPI ID	Description	Validation mechanism	Success criteria
KPI29	Cost savings per season (Botrytis detection, phytosanitary treatments, transport)	Baseline will be measured prior to the adoption of FlexiGroBots technologies.	> = 30% per crop season
KPI32	Number of different tasks robots are able to carry out	Soil sampling and pesticide spraying functionalities developed	>= 2
KPI33	Number of new different services offered to farmers	Weed/disease spraying, soil sampling operational	>= 2
KPI37	Number of components compatible with IDSA and OGC standards implemented and/or integrated within the system	Weed/disease maps, georeferenced soil samples and targeted pesticide application following the OGC standard, while all UAV/UGV data following IDSA standards	>= 5
KPI43	Reduction of pesticide usage	Comparison between "blanket" application vs. targeted application of pesticides	40%
KPI45	Reduce cost soil sampling	Commercial cost per soil sample compared to the cost of robot operation	35%
KPI46	Reduce the cost of potential damages from sub-optimal pesticide application	Calculation of the typical costs of weed/disease damages vs. the cost of robot operation + raw materials (pesticides)	25%

Table 11 Validation of relevant KPIs for pilot 3

5.4 Summary of the relevance of KPIs for pilots

KPI ID	Description	Pilot 1	Pilot 2	Pilot 3	Overall value
KPI3	Demonstrators using more than 90% of the MCC services	= 1	= 1	= 1	3
KPI6	Number of data sets shared within the pilots	>=4	>=2	>=2	>= 8

KPI ID	Description	Pilot 1	Pilot 2	Pilot 3	Overall value
KPI7	Number of pilots using georeferenced agriculture-related data analytics	= 1	= 1	= 2	= 4
KPI8	Number of datasets shared with third parties via ADS	>=2	>= 2	>=2	>= 6
KPI9	Number of novel agricultural AI methods or Machine Learning (ML) models	=>2	> 3	>=2	>= 7
KPI10	Number of potential new products and services based on those new AI methods / ML models	>=2	=> 2	>=2	>= 6
KPI12	Pilots for Assessment List of the Ethics Guidelines for Trustworthy AI	= 1	= 1	= 1	= 3
KPI14	Platform assessment (cross-pilot)	=1	= 1	= 1	= 3
KPI15	Demonstrators incorporating both UAV and UGV robotic platforms	=1	= 1	= 1	= 3
KPI16	Number of robots taking part in demonstrated multi-robot systems	>= 2	>= 4	>= 2	>= 8
KPI17	Number of DIHs with the capability of demonstrating FlexiGroBots pilots the project ends	>=1	= 1	>= 2	=> 4
KPI18	Number of real-world pilots	1	1	2	= 4

KPI ID	Description	Pilot 1	Pilot 2	Pilot 3	Overall value
KPI19	Numbers of regions where the FlexiGroBots demonstrators are deployed and run	1	1	2	= 4
KPI20	Number of demonstrators deployed and running in different regions			1	= 1
KPI21	Demonstrators showing AI4EU marketplace use cases	= 1	= 1	= 2	= 4
KPI22	Number of agricultural Machine Learning (ML) models contributed to the AI4EU marketplace	= 3	>=3	>=2	>=8
KPI26	Number of DIHs actively engaged in pilots' development and demonstrations	= 2		=3	= 5
KPI28	Average percentage of improvement in the performance of tasks by robots	> = 25%	>= 50%	> = 25%	Use-case dependent
KPI29	Cost savings per season (Botrytis detection, phytosanitary treatments, transport)	>= 20%		> = 30% per crop season	Use-case dependent
KPI32	Number of different tasks robots are able to carry out	>= 3	>= 5	>=2	>= 10
KPI33	Number of new different services offered to farmers	>= 3	>= 6	=>2	>= 11
KPI34	Single pilot duration	>= 1 hour	>= 30 minutes		Use-case dependent

KPI ID	Description	Pilot 1	Pilot 2	Pilot 3	Overall value
KPI37	Number of components compatible with IDSA and OGC standards implemented and/or integrated within the system	>= 5	>= 5	>=5	>= 15
KPI38	Reduce the use of the phytosanitary product, minimize costs and environmental damages	>= 20%			Use-case dependent
KPI39	Reduce the cost of grape transport	Baseline: 220€/h per season Improv: 11% Target: 195 €/ha per season.			Use-case dependent
KPI40	Reduce time of grape transport	Baseline: 180 min Improv: 50% Target: 90 min			Use-case dependent
KPI42	Autonomous tractor operation		= 1		Use-case dependent
KPI43	Reduction of pesticide usage	Baseline: 155€/h per season Improv: 9% Target: 141 €/ha per season	<= 75%	40%	Use-case dependent
KPI45	Reduce the cost of potential damages			35%	Use-case dependent

KPI ID	Description	Pilot 1	Pilot 2	Pilot 3	Overall value
	from sub-optimal pesticide application				
KPI46	Reduce the cost of potential damages from sub-optimal pesticide application			25%	Use-case dependent
KPI47	Work efficiency.		<= 50% per added simultaneously operating working unit.	.	Use-case dependent
KPI48	Reduce inspection costs	Baseline: 86€/ha. Improv: 30% Target: 59,5 €/ha			Use-case dependent
KPI49	Decrease environmental load saving pesticides		<= 75%		Use-case dependent
KPI50	Increased safety. Robotics together with an External situation monitoring system has the capability to create a more comprehensive view of the situation		>= 1		Use-case dependent
KPI51	Rumex mapping. The existence of Rumex-weeds enables targeted weeding operations thus decreasing manual labour needs		>= 80%		Use-case dependent
KPI52	Less laborious manual work for pests mapping		<= 50%		Use-case dependent

KPI ID	Description	Pilot 1	Pilot 2	Pilot 3	Overall value
KPI53	Identification comparison to manual detection of pests.		>= 90%		Use-case dependent
KPI54	The harvesting timing can be improved thus providing more digestible dry matter.		>= 1 % more digestible dry matter from selected fields		Use-case dependent
KPI55	Weeding efficiency		>=50%		Use-case dependent

6 Discussion and conclusions

This document presents the methodology that has been followed during the first year of the project in order to maximise the synergies and to achieve the convergence between the three pilots, reaching the needed common ground for the elicitation of the project requirements and the design of the platform architecture in a consistent manner.

The methodology has been focused on the production of detailed descriptions of the pilots' use cases following the standard IEC 62559 templates as a vital step to extract functional and non-functional requirements to feed the work done by T2.2 and reported in D2.2. An exhaustive analysis of the different datasets that have been generated during the first tests in the fields has been also requested as the second pillar of the methodology. The importance of this aspect is also very high due to the need to train multiple services powered by Machine Learning models. Therefore, data scientists must have access as soon as possible to the information so that the first prototypes can be developed and integrated into the pilots' systems for the next trials. The templates proposed by *D1.3 Data Management Plan* were used to gather this information. The third step followed in the process was to increase the level of technical detail and to elaborate comprehensive studies about the different devices, robots and digital systems that are part of the pilots' use-cases, including their interfaces and APIs to facilitate the interoperability and integration into the overall project platform. The corresponding descriptions are the main bases for the content of D4.1, D5.1 and D6.1 which are already delivered in M12 of the project.

On the basis of the results of the process driven by T2.5 in collaboration with WP4, WP5 and WP6, the architecture proposed by T2.2 for the FlexiGroBots platform was analysed and mapped against the specificities of each one of the pilots, paying special attention to the following aspects: particularisation of the data space concept, applicable common services and interactions between the Mission Control Centre and the different ground and aerial robots.

The document concludes with two elements that will be key for the successful execution of the project in the next months: the planning for future actions including the elaboration of a backlog of tasks with priorities and the study of the key performance indicators (KPIs) related to each pilot, indicating the validation mechanisms and the target goals.

The future steps for the continuation of the work of T2.5 will be strongly linked to these two latter aspects. The task will establish periodic meetings between the leaders of the three project pilots in order to monitor the correct progress according to the initial plan included in the present document and to drive the integration process of the horizontal FlexiGroBots platform. In this sense, as presented in this deliverable, the project will adopt an agile methodology based on sprints. The results of this process will be reported as part of the next version of the deliverable in D2.8 together with the updates for the assessment of the KPIs.

References

[1] FlexiGroBots deliverable D2.1 - Stakeholder view to FlexiGroBots system scenarios.

[2] FlexiGroBots deliverable D2.2 - Requirements and platform architecture specifications.

[3] International Electrotechnical Commission Standard IEC 2559-2:2015 Use case methodology - Part 2: Definition of the templates for use cases, actor list and requirements list. https://webstore.iec.ch/publication/22349

[4] FlexiGroBots deliverable D4.1. - Pilot 1 objectives, requirements and design.

[5] FlexiGroBots deliverable D5.1. - Pilot 2 objectives, requirements and design.

[6] FlexiGroBots deliverable D6.1. - Pilot 3 objectives, requirements and design.

[7] FlexiGroBots deliverable D1.3 - Data Management Plan.

Annex 1 – FlexiGroBots KPIs (DoA)

KPI ID	KPI Description	Success criteria	WP(s) Responsible
1	Mission Control Centre (MCC) reference architecture	1	WP2
2	MCC solution building block implementations	>= 8	WP3
3	Demonstrators using more than 90% of the MCC services	>= 3	WP4, WP5, WP6
4	Agricultural Data Space (ADS) reference architecture	>=1	WP2, WP3
5	ADS solution building blocks	>= 12	WP3
6	Number of data sets shared within the pilots	>= 6	WP4, WP5, WP6
7	Number of pilots using georeferenced agriculture-related data analytics	>= 2	WP4, WP5, WP6
8	Number of datasets shared with third parties via ADS	>= 4	WP4, WP5, WP6
9	Number of novel agricultural AI methods or Machine Learning (ML) models	>= 6	WP4, WP5, WP6
10	Number of potential new products and services based on those new AI methods / ML models	>= 2	WP4, WP5, WP6
11	Graphical user interface for the human operator to oversee and be engaged in the control loop	>= 1	WP3
12	Pilots for Assessment List of the Ethics Guidelines for Trustworthy AI	>= 3	WP2, WP4, WP5, WP6
13	Platform assessment (cross-pilot)	>= 1	WP2
14	Numbers of crops addressed in the pilots	>= 3	WP4, WP5, WP6
15	Demonstrators incorporating both UAV and UGV robotic platforms	>= 3	WP4, WP5, WP6
16	Number of robots taking part in demonstrated multi-robot systems	2	WP4, WP5, WP6
17	Number of DIHs with the capability of demonstrating FlexiGroBots pilots the project ends	>= 3	WP4, WP5, WP6, WP7
18	Number of real-world pilots	3	WP4, WP5, WP6
19	Numbers of regions where the FlexiGroBots demonstrators are deployed and run	4	WP4, WP5, WP6

KPI ID	KPI Description	Success criteria	WP(s) Responsible
20	Number of demonstrators deployed and running in different regions	1	WP6
21	Demonstrators showing AI4EU marketplace use cases	>= 2	WP4, WP5, WP6
22	Number of agricultural Machine Learning (ML) models contributed to the AI4EU marketplace	>=6	WP3, WP4, WP5, WP6
23	Number of new integrations of the AI4EU marketplace with other Agricultural Data Space (ADS) enablers (following the FlexiGroBots reference architecture)	3	WP3, WP4, WP5, WP6
24	Guidelines and recommendations to address ELSE in AI-driven robotics in Agri-Food	>= 1	WP2, WP7
25	Number of workshops or webinars made through the AI4EU Observatory	>=3	WP7
26	Number of DIHs actively engaged in pilots' development and demonstrations	>= 6	WP4, WP5, WP6, WP7
27	Number of DIH networks engaged to maximise long-term sustainability	>=3	WP7
28	Average percentage of improvement in the performance of tasks by robots	> = 25%	WP4, WP5, WP6
29	Cost savings per season (Botrytis detection, phytosanitary treatments, transport)	> = 30% per crop season	WP4, WP5, WP6
30	Number of DIHs with capability of demonstrating FlexiGroBots pilots after the end of the project	>=3	WP7
31	Number of joint business models proposed	>= 2	WP7
32	Number of different tasks robots are able to carry out	>= 2	WP4, WP5, WP6
33	Number of new different services offered to farmers	>= 2	WP3, WP4, WP5, WP6
34	Single pilot duration	>= 1 hour	WP4, WP5, WP6
35	Availability of online platform services within Mission Control Centre and Data Space	>= 95%	WP3
36	Full integrity with the current ISOBUS standard	1	WP3

KPI ID	KPI Description	Success criteria	WP(s) Responsible
37	Number of components compatible with IDSA and OGC standards implemented and/or integrated within the system	>= 10	WP3, WP4, WP5, WP6
38	Reduce the use of the phytosanitary product, minimize costs and environmental damages	0,09	WP4
39	Reduce the cost of grape transport	0,11	WP4
40	Reduce time of grape transport	0,5	WP4
41	Used time and accuracy for multi-robot fleet management systems	0,05	WP5
42	Autonomous tractor operation	1 driver's cost	WP5
43	Reduction of pesticide usage	0,75	WP5
44	Number of end users adopting Pilot 2 technology solution	1 end user	WP5
45	Reduce cost soil sampling	0,35	WP6
46	Reduce cost of potential damages from sub-optimal pesticide application	0,25	WP6
47	Cut in pesticide application	0,4	WP6