Deliverable D5.3

D5.3 Testbed Deployment, System Extensions and Applications for Pilot Round 1 v1.6

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1 Executive Summary

In DEMETER, 20 experimental pilots will be deployed in 18 European countries which have been grouped into 5 thematic clusters:

1. Arable Crops: Water + Energy Management
2. Arable Crops: Agricultural Machinery, Precision Farming
3. Fruits and Vegetables: Healthy and High-Quality Crops
4. Livestock: Animal Health, High Quality & Optimal Management of Animal Products
5. Cross-Sectorial: Full Supply Chain, Interoperability, Robotics

These pilots were planned with the idea of overcoming specific challenges which were translated into objectives and key performance indicators (KPIs) that will allow these pilots, not only to measure their achieved impact and goals, but also to serve them as a guideline in the development of their activities.

On the other hand, DEMETER delivered an initial release of a Reference Architecture (RA), described in detail in the deliverable D3.2 *DEMETER Technology Integration Tools*, based on a thorough analysis of the requirements imposed by the pilots' stakeholders and guided by the DEMETER vision in a holistic multi-actor approach. In order to implement this RA, one of the most crucial technological components developed has been the common data models that conforms the DEMETER Agriculture Information Model (AIM), described in detail in the D2.1 *Common Data Models and Semantic Interoperability Mechanisms - Release 1.* These data models allow for the semantic interoperability between DEMETER and other Agrifood systems. This initial release of the RA along with the AIM will be used to guide the development of the technologies and the DEMETER enabled apps for the first round of the deployment of DEMETER's pilots. The integration of these pilots in the DEMETER's environment will be done with the help of two cornerstone components of DEMETER, the DEMETER Enabler Hub (DEH) and the Brokerage Service Environment (BSE), described in detail in the deliverable D3.2. Because of the importance these two components have in the pilot integration, we have also summarised them so that the integration process could be better understood.

In this document you will find the progress that DEMETER has made regarding the consecution of the KPIs mentioned above for each of the general objectives thanks to the contribution of all the pilots. Additionally, so that not to interfere with the reading of the document, each of the pilot contribution for these KPIs have been moved to an Annex.

According to Task 5.3 (*Pilot roll-out and execution management*), this deliverable is focused on providing a first round of the pilot integration, capturing the results of the pilot's setup and system deployment at pilots' sites, there is a section which explains the deployment plan followed by all pilots explaining each of two rounds their phases and the specific activities. Afterwards there is a dedicated section for each of the pilot where a short description is provided focusing on two interesting aspects: how the information flows inside the pilot, the used data, and which are the required extensions and adaptations for the pilots so that it could be integrated into the DEMETER environment. For each of these aspects a dedicated section has been designed.

The first of these sections usually contains specific diagrams and the corresponding explanation of how the information is acquired and how it traverses the different modules or components which were designed by the specific solutions and applications the pilot is using. The description of the used data does not only contemplate the specific information already managed by the specific solutions used by the pilots, but it also makes a reference to the cross-domain ontology and specific-domain ontologies defined in the AIM. Finally, regarding the extensions and applications required for each of the pilot, there is a section which firstly provides a specific instantiation of the DEMETER reference architecture. Taking advantage of this picture, each of the pilot develop the integration process by identifying the different components of the DEMETER reference architecture they use, and how the pilot is linked to them.

Moreover, each of the pilot has designed a specific deployment plan identifying each of the two rounds, as well as their phases and activities which is illustrated thanks to the use of a Gantt diagram. Each of them has been moved to a specific Annex.

Finally, in the scope of Task 5.5 (*Cross-Pilot Coordination, Fertilization and Optimization*) there is a specific section which highlights the adoption of the components defined in Work Packages 2, 3 and 4 in this first pilot round, finding synergies and common interests among them. In order to illustrate such adoption specific mapping tables for each of the Work Packages have been defined.

2 Document History

Version	**Author**	**Description**
0.1	OGC-OdinS	First Draft with TOC
0.2	OdinS	Updated version, confirmed with contributors and agreed on distribution of work
0.3	All mentioned authors (see table below)	Updated version, comments and adjustments from partners reviewed by OdinS.
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1.6	Martin Klopfer (OGC)	Minor corrections

3 Acronyms

ACS	Access Control Server
AES	Advanced Encryption Standard
AgIoT	Iot Solution for Agrifood Sector
AI	Artificial Intelligence
AIM	Agriculture Information Model
API	Application Programming Interface
AT	After Treatment
BS	Brokerage Server
BSE	Brokerage Service Environment
CoAP	Constrained Application Protocol
CSV	Comma Separated Values
DCAT	Data Catalog Vocabulary
DDS	Data Distribution Service
DEE	DEMETER Enhanced Entities
DEH	DEMETER Enabler Hub
DIM	Days In Milk
DLT	Distributed Ledger Technology
DOC	Diesel Oxidation Catalyst
DPF	Diesel Particulate Filter
DSS	Decision Support System
dt	Deci tonne (100kg)
eDWIN	Online Consulting and Decision Support Platform in Integrated Plant Protection
EGNOS	European Geostationary Navigation Overlay Service
EGNSS	European Global Navigation Satellite System
EGR	Exhaust Gas Recirculation
EO	Earth Observations
FADN	Farm Accountancy Data Network
FAPAR	Fraction of Absorbed Photosynthetically Active Radiation
FMIS	Farming Management Information Systems
GIS	Geographic Information System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GSM	Global System for Mobile Communications
ha	Hectare
HW	Hardware
ICT	Information and Communications Technology
IoT	Internet of Things
ISM	Industrial, Scientific and Medical
KPIs	Key Performance Indicators
KTBL	Kuratorium für Technik und Bauwesen in der Landwirstscharft (ASSOCIATION FOR TECHNOLOGY AND STRUCTURES IN AGRICULTURE)
LED	Light Emitting Diode
LFA	Less-Favoured Areas
MAA	Multi Actor Approach
MEMS	Microelectromechanical Systems

MEP	Mission Exploitation Platform
ML	Machine Learning
MQTT	Message Queuing Telemetry Transport
NCDX	Nordic Cattle Data exchange
NDMI	Normalized Difference Moisture Index
NGSI / NGSI-LD	Next Generation Service Interface / - Linked Data
NPK	Nitrogen, Phosphorus, and Potassium Fertilizer
NUTS	Nomenclature of Territorial Units for Statistics
NDVI	Normalized Difference Vegetation Index
NUTS	Nomenclature of Territorial Units for Statistics
OGC	Open Geospatial Consortium
OWL	Web Ontology Language
PEMS	Portable Emission Measurement Systems
RDF	Resource Description Format
REST	Representational State Transfer
SAAS	Software as a Service
SCP	Specialty CropsPlatform
SHACL	Shapes Constraint Language
SKOS	Simple Knowledge Organization System
SOAP	Simple Object Access Protocol
SOCS	Stakeholders Open Collaboration Space
SQuaRE	Software product Quality Requirements and Evaluation
SR	Service Registry
SW	Software
UAV	Unmanned Airborne Vehicle (e.g. Drones)
UC#	Use Case
UGV	Unmanned Ground Vehicles
VRA	Variable Rate Application (e.g. of fertiliser or pest treatments)
WAN	Wide Area Network
WFS	Web Feature Service Standard of the Open Geospatial Consortium
WIG	WatchITgrow platform
WMS	Web Mapping Service Standard of the Open Geospatial Consortium
WP	Work Package

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5 Introduction

This report captures the results of the Pilot setup and system deployment at pilot sites, considering all systems extensions and applications to be introduced in pilots' round 1. In addition, this report summarizes the initial results of *Task 5.2: Pilot Testbed Management, Pilot Applications, System Extensions and Deployment at Pilot Sites*. This task was conceived with the objective of identifying single pilot site requirements for hardware and software adaptation and integration and is complemented by the work carried out in parallel in *Task T5.5 (Cross-Pilot Coordination, Fertilisation and Optimisation)*.

In this first round, the setup of the pilot and its integration into the DEMETER environment will require customising and integrating identified components. This includes customisation & integration of SW/HW external to DEMETER, such as Applications, User Interfaces & Smart Objects, as well as customisation/extension of the DEMETER enablers that is necessary only for a specific site of each pilot. Configuring and testing the integration will be considered in a following step.

The findings presented in this document are/will be complemented by the following reports as they become available:

- D3.1 DEMETER reference architecture (March 2020)
- D2.2 DEMETER Data and Knowledge extraction tools (June 2020)
- D4.2 Decision Enablers, Advisory Support Tools and DEMETER Stakeholder Open Collaboration Space (July 2020)
- D5.2 Revised Stakeholder requirements, pilots design, and specification (May 2020)
- D3.3 DEMETER reference architecture (March 2021)

6 Testbed Deployment, System Extensions and Applications for DEMETER Pilots

Along this section we are going to describe the procedure to deploy the DEMETER's pilots and the needed adaptations required for them to be integrated in DEMETER.

All the pilots in DEMETER are described in individual sections to describe their use case workflow, used data, as well as the extensions and applications they require.

In this section, a table with the DEMETER's objectives and KPIs is defined for the pilots to provide their measured goals and achieved impact which will contribute to the global ones. DEMETER defines six main objectives to empower farmers not only to better exploit their existing operational context to extract knowledge so they can improve their decisions but also to ease the acquisition, evolution and update of their context by focusing their investments where these are needed based on their goals. For each objective, these goals are measured by different KPIs. All pilots' contributions to the achievement of these overall objectives are described by filling specific tables, in Annex 2 – Contribution to objectives and KPIs per pilot.

6.1 Pilot Round 1 Planning and Tracking

The deployment procedure for the pilots is performed in two **rounds** as described in Task 5.3 "Pilot roll-out and execution management". The first round focuses on the input of the stakeholders, with different tasks to set up the experimental design with farmers, for pilot testing or to develop a decision support system. The second round focuses on the interoperability and technical aspects of the pilot with tasks for tuning or implementing system improvements.

Pilots' deployment execution is also divided in three main **phases**:

- Phase 1 - State of the art analysis: existing domain processes, technology assessment and definition of requirements.
- Phase 2 - Implementation: acquisition and integration of needed technologies and data capture, analysis and integration.
- Phase 3 - Testing and dissemination: use DEMETER integrated platforms to increase the productivity and track the product along the supply chain.

Each pilot outlines its implementation plan where we can find all the needed tasks to be executed along these two rounds and phases. To do so, each of the pilot presents a Gantt diagram following specific colours as described next:

- Black colour - means sub task specification;
- Green colour - means mandatory DEMETER WP5 deliverable;
- Red colour – highlights sub task specification for round 1 of pilot application;
- Blue colour – highlights sub task specification for round 2 of pilot application;
- Orange colour – highlights tasks that have been performed faster than planned
- The Gantt has a timeline representation (in project months and in calendar months);
- Each activity is specified by the timeline of the expected and actual implementation.

As a lot of details are represented on each diagram, we have decided to put each pilot implementation plan in Annex 4 – Implementation plans.

6.2 DEMETER Enabler Hub and Brokerage Service Environment

Regarding the integration of the pilots in the DEMETER environment, there are two key components that deserve a brief description so that the bigger picture of the integration can be better understood. These two components are the DEMETER Enabler Hub, and the Brokerage Service Environment which are crucial for this integration and are described in detail in the deliverable D3.2 "DEMETER Technology Integration Tools" along with the technologies used for their implementation.

6.2.1 The DEMETER Enabler Hub

In a brief description, the DEH component represents the digital space dedicated to end users of DEMETER where they will be able to create and register their own resources. It is composed of three main modules:

- **DEH Dashboard** functional module, covering User Interaction and Data Visualisation. It will allow users to login, discover, register and manage other DEMETER Resources. This front-end application will be provided by ENGINEERING and will use a technology developed within its research laboratories namely the DYMER.
- **DEH Security APIs** module, that provides the support for connecting with the User Authentication and Authorization blocks that contain information related to users, such as personal data, credentials, and also access policies.
- **DEH Core** functional module, that is in charge for managing DEMETER Resources. It will manage the creation, edition, deletion and discovery of DEMETER Resources. It is composed of three internal components which will be available as SaaS (Software as a Service): the DEH Resource Registry Management module, the DEH Discovery Management module and the Compatibility Checker module.

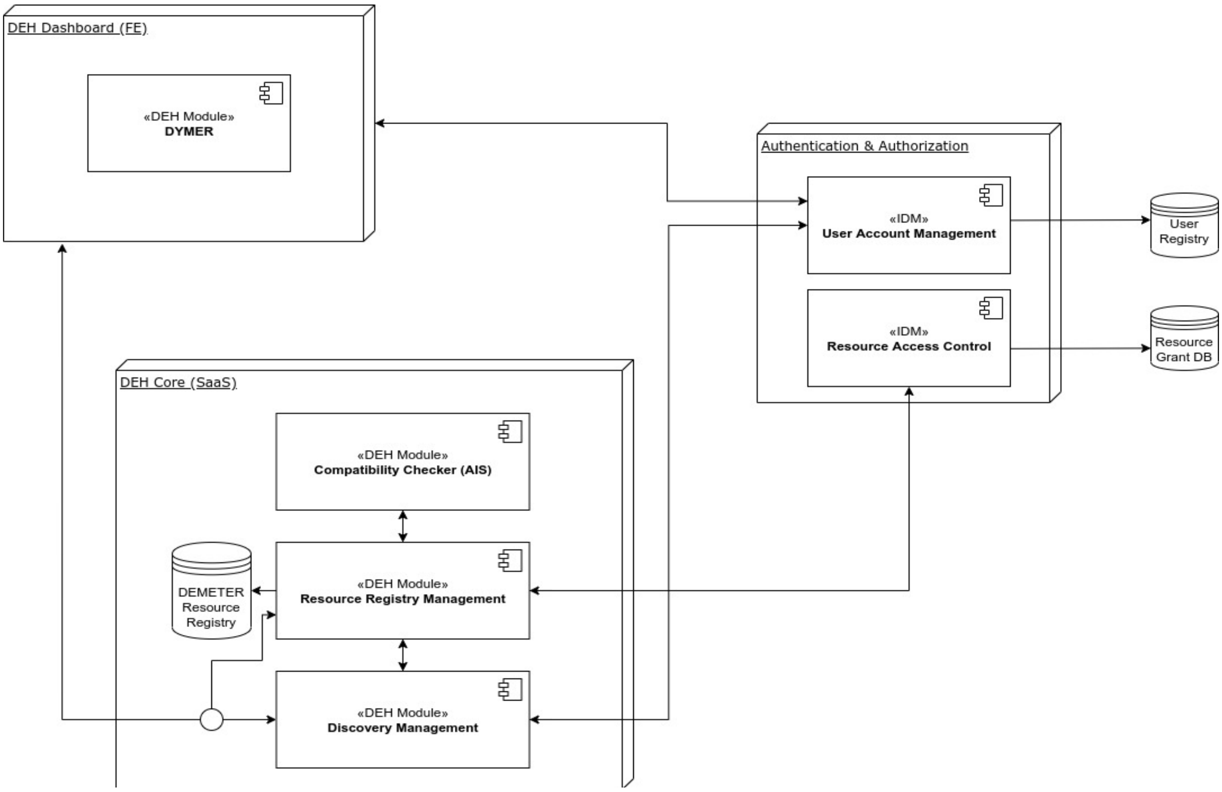

Figure 1: DEMETER Enabler HUB component diagram

These components expose endpoints through their internal APIs and will be made available for deployment via docker[1] containerization. Pilots will use this deployment to integrate with the DEH.

6.2.2 The Brokerage Service Environment

The BSE component facilitates the registration, discovery and ultimately communication process for the DEMETER Resources in a secure and privacy preserving manner.

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[1] https://docs.docker.com/

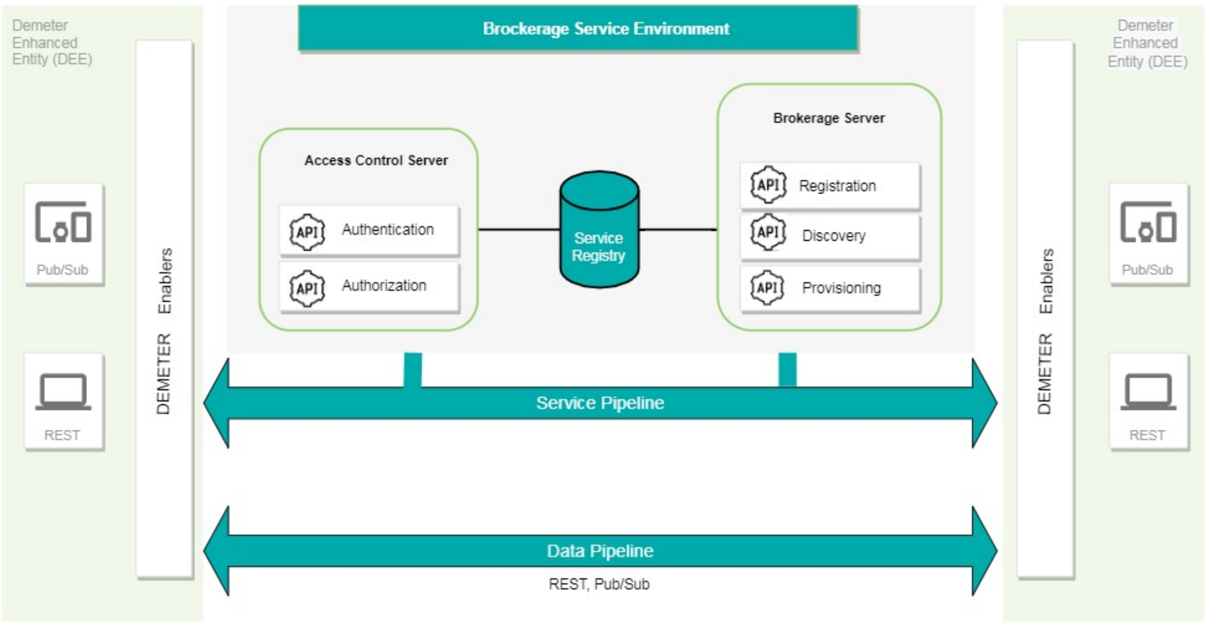


Figure 2: BSE component diagram

There are three main components in the BSE:

- **The Access Control Server** (ACS), that provides the access to the security components of Authentication, Authorisation and Traceability.
- **The Service Registry** (SR), that is used to store user and service-related meta data in a persistent manner. It implements a RESTful interface through which it communicates with Access Control Server and with the Brokerage Server.
- **The Brokerage Server** (BS), which purpose is to facilitate the registration, discovery, and provisioning service.

The BSE will be implemented as a self-contained application that would enable an external party to deploy it as a complete brokerage service solution. Once integrated with the BSE, all the data gathered from the pilots will be published through it.

6.3 *Impact and Success Criteria - KPIs*

To measure the accomplishment level of the DEMETER objectives have been achieved, a number of KPIs have been established for each objective. The following tables present the progress regarding the achievement of these KPIs. For this reason, we have identified two columns for specifying the target objective and what we have achieved up to this moment.

Table 1: General objectives and KPIs including progress achieved to date

Objective #1 – Information Modelling & Objective #2 – Knowledge Exchange Mechanisms		**Target**	**Achieved to date**
	DEMETER interoperability mechanisms implemented	>= 50	**12**

Agriculture Interoperability Space deployed	Number of solutions present in DEMETER	>= 100	**34**
	Number of different suppliers involved in DEMETER	>= 60	**77**
	Number of external components / data hubs connected to DEMETER	>= 5	**27**
	New deployments at farmers (see pilots and open calls)	>= 30	**>131**
	Number of harmonization's and contributions to standards	>= 10	**12**
	Volume of data observing the information models	>=20 exabytes	**> 70GB/h**

Objective #3 – Data Ownership		**Target**	**Achieved to date**
Farm context model including inventory of data sources.	available	availability	**Yes, e.g.** Information obtained from farms (in NGSI or MEGA) thanks to Smart Agriculture platform and MEGA Coordinator; AIM model; National herd recording system (Norwegian), Eana Ku; AFarCloud's information model;
New business models defined and adopted	available	availability	**Yes, e.g.** Poultry well-being by introducing premium line of products; Poultry based on traceability and data exchange;
Data exchange mechanisms implemented within DEMETER	Number of data exchanges (with financial retribution of farmers)	>= 50	So far, we have identified technologies, but not the number of data exchanges that will be produced.

Exposure of farmer sourced data through DEMETER	Number of data sharing agreements	>= 500	**96**

Objective #4 – Benchmarking		**Target**	**Achieved to date**
Proposed benchmarking mechanism elaborated with participation of over 500 farmers	Comparison / selection of solutions during DEMETER's lifetime	>= 30	**44**
	Water and pesticide usage per yield unit and per hectare	>= decrease on 15%	**This objective is identified in several pilots such as P1.1&1.2 or Pilot 1.3 but the consecution to this KPI will be checked after their deployment**
	Number of tools and datasets tried in pilots	>= 5.000	**So far, we have identified and named a total of 28 tools and 130 datasets.**

Objective #5 – User Oriented Solutions		**Target**	**Achieved to date**
Running 'challenges' based on farmer needs.	Groups of suppliers teaming up to address needs expressed by farmers	>= 30	**16**
Open co-creation space for suppliers to team up and answer farmer needs.	Number of farms addressed	> 50.000	**>1600**

Objective #6 – Real World Impact		**Target**	**Achieved to date**
Fully deployed DEMETER ecosystem	Service advisors sign up to DEMETER	100	**10** service advisors have been identified in this first round

	Suppliers of solutions sign up to DEMETER	100	**11**
	Pilots deployed across different sectors	5	**6**

This table is detailed in Annex 1 where a list per objective is provided. Additionally, in Annex 2 each pilot's contribution to the overall objectives and KPIs is also detailed.

7 Pilot 1.1&1.2 - Water Savings and Smart Energy Management in Irrigated Crops& Arable Crops

Pilot 1.1&1.2 aims to increase the production of irrigated crops while saving water and energy. The pilot will be deployed in two specific locations of the Spanish territory thanks to the collaboration with two different irrigation communities: "Left side of Porma River" Irrigation Community ("Comunidad de regantes canal margen izquierda del Porma"), in the Castilla & León Region with the support of TRAGSA, and Irrigation Community Campo de Cartagena ("Comunidad de Regantes Campo de Cartagena)" in the Murcia Region, where Odin Solutions and the Universidad de Murcia are also involved.

This pilot will use inputs from both soil sensors and meteorological stations, as well as satellite images to optimise the irrigation system.

7.1.1 Use Case Workflow

For this pilot, we have considered as inputs the soil and weather information provided by soil sensors and a weather station, as well as satellite images and the different indices they offer among others. Figure 3 presents a general picture of how this information is gathered through the different IoT platforms (SmartAgriculture and MEGA Coordinator), tailored to DEMETER Enriched Entities (DEEs), and integrated into the DEH.

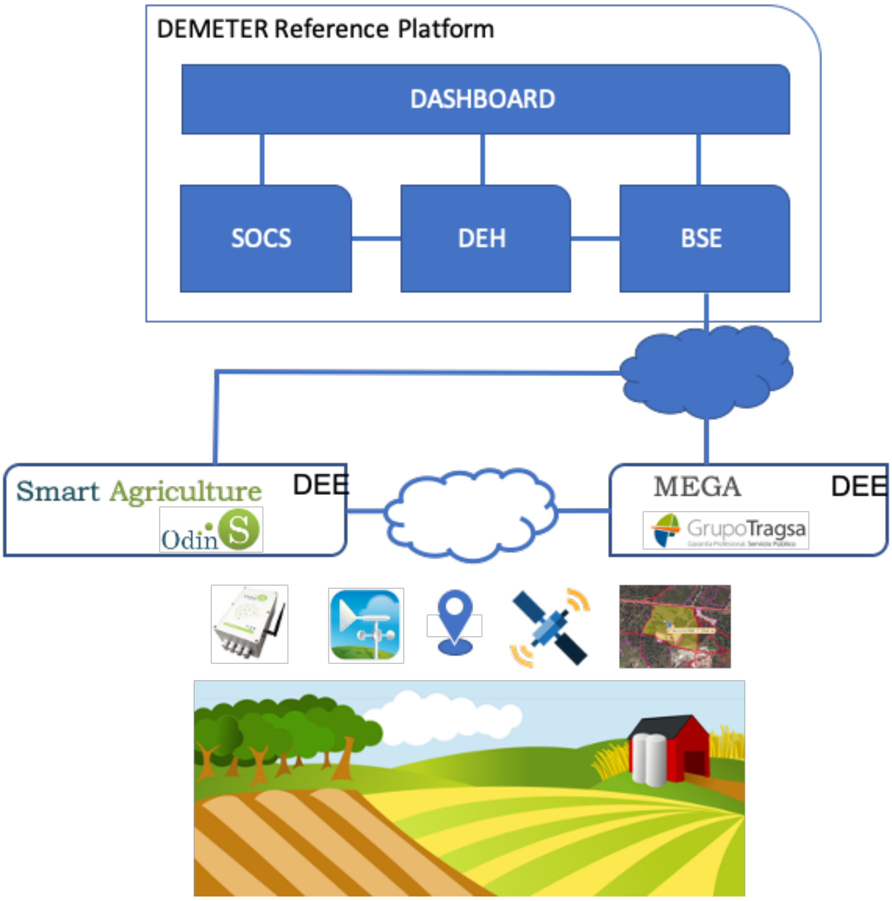
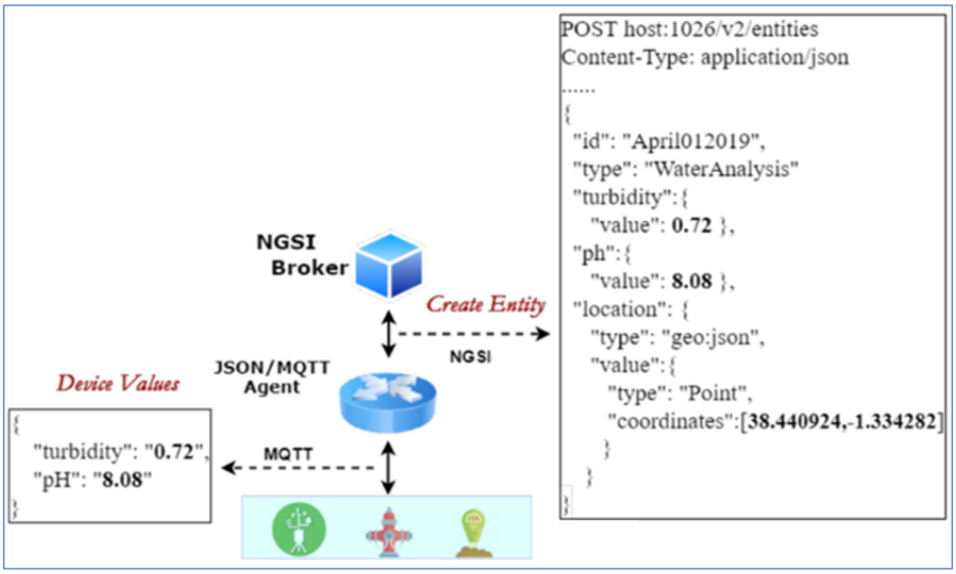


Figure 3: Example of Pilot 1.1&1.2 flow of information

The information provided by IoTGateways follows open and standard protocols such as JSON documents over MQTT. This way, the information is translated to a richer representation format by using NGSI as exemplified in Figure 4.

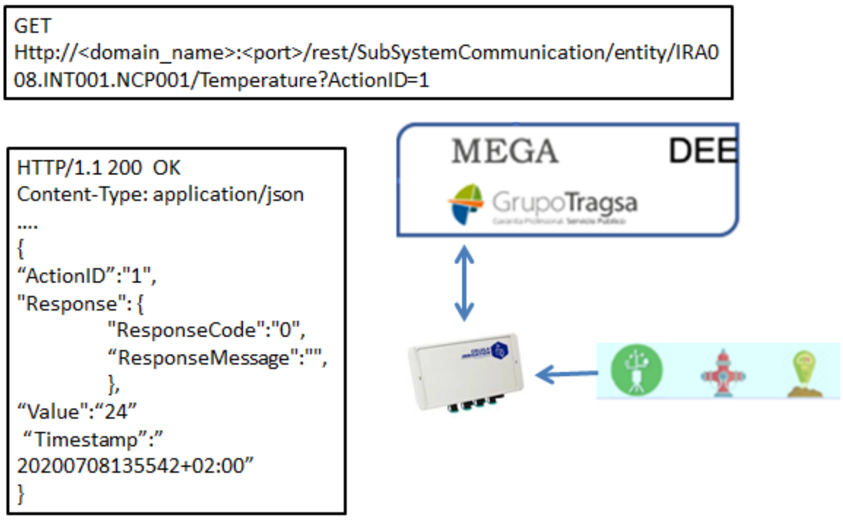


```
{
  "turbidity": "0.72",
  "pH": "8.08"
}
```

```
POST host:1026/v2/entities
Content-Type: application/json
......
{
 "id": "April012019",
 "type": "WaterAnalysis"
 "turbidity":{
   "value": 0.72 },
 "ph":{
   "value": 8.08 },
 "location": {
   "type": "geo:json",
   "value":{
     "type": "Point",
     "coordinates":[38.440924,-1.334282]
     }
   }
}
```

Figure 4: IoT level information translated to NGSI

Some of the irrigation control systems with whom we work have their own sensors that cannot be accessed directly. To access this information we use ISO 21622 and through MEGA we can get this information as indicated in Figure 5.



```
GET
Http://<domain_name>:<port>/rest/SubSystemCommunication/entity/IRA0
08.INT001.NCP001/Temperature?ActionID=1
```

```
HTTP/1.1 200  OK
Content-Type: application/json
....
{
“ActionID”:"1",
"Response": {
            "ResponseCode":"0",
            “ResponseMessage":"",
            },
“Value":“24”
 “Timestamp”:”
20200708135542+02:00”
}
```

Figure 5: Getting sensor information through MEGA

Thanks to the DEMETER Enablers Client-side, the MEGA DEE can be integrated into the DEMETER Reference Platform comprised by the DEMETER Service Environment, DEMETER Enabler Hub (DEH), DEMETER Stakeholder Open Collaboration Space (SOCS) and Dashboard. This way, this information can be exchanged also with other platforms. This process is made in a secure manner thanks to the use of the DEMETER authorisation component guaranteeing that only legitimate users with the right permissions access to the corresponding information.

7.1.2 Used Data

This pilot is aimed at the optimisation of water and energy resources for arable crops. For this reason, the data it manages includes:

- Geospatial data: location, Geographical Information System (SigPac), EGNSS (GPS/EGNOS/Galileo)
- Satellite imagery: Copernicus Sentinel 2
- Climate data: Air temperature, air humidity, wind speed, wind direction, solar radiation and rain
- Soil data: temperature, salinity, humidity, conductivity, soil water tension, soil water content, soil water height
- Water data: hydrants (water flow and water consumption)
- Farm data: historical farm statistics, farm crop data

Additionally, this pilot manages other general information related to users and companies such as username/password, personal information, or that related to companies. This information is modelled thanks to the Agriculture Information Model (AIM) already defined in Deliverable 2.1 through the AgriFood Data Model. Below we detail the concepts more related to the agricultural domain.

```
"@context": {
   …
   "Plot": "http://foodie-cloud.com/model/foodie#Plot",
   …
   "CropSpecies" : "http://foodie-cloud.com/model/foodie#CropSpecies",
   …
   "creationDateTime" : {
      "@id" : "http://foodie- cloud.com/model/foodie#creationDateTime",
      "@type": "xsd:dateTime"
   },
   "cropSpecies" : {
      "@id" : "http://foodie-cloud.com/model/foodie#cropSpecies",
      "@type": "@id"
   },
   "originType" : {
      "@id" : "http://foodie-cloud.com/model/foodie#originType",
      "@type": "@id"

   },
   …
}
```

These concepts were also defined in D2.1 and integrated into the AIM thanks to the reuse of specific ontologies related to agriculture features, crops, alerts, properties and systems.

7.1.3 System Extensions and Applications

In this section we are describing how this pilot is integrated into the DEMETER environment, including which DEMETER components are required, and what sort of integration should be carried for this specific pilot in terms of customization of SW/HW external to DEMETER, applications, interfaces, as well as the customisation/extension of the DEMETER enablers needed for a specific site of each pilot.

Figure 6 shows the instantiation of the Reference Architecture defined in DEMETER for pilot 1.1&1.2:

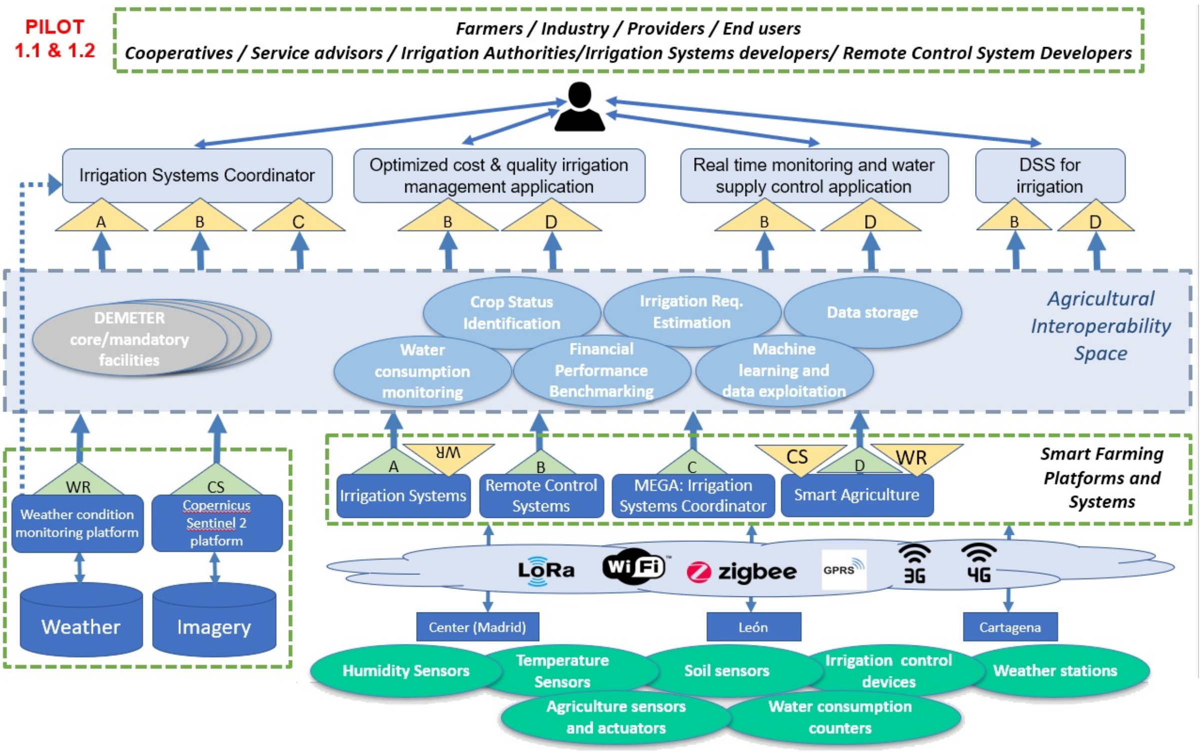


Figure 6: Reference architecture instantiated for Pilot 1.1&1.2

This figure presents the mapping of the DEMETER architecture to the pilot, the delivery of apps through it and the composition of such apps from DEMETER enabled entities, data and services. The raw resources (e.g. various types of devices) are presented at the bottom. They are connected through the appropriate communication protocols (LoRa, WiFi, etc.) to existing Farming Management Information Systems (FMIS) or IoT Device Platforms. In this pilot we can find:

- Irrigation systems
- Remote control systems: outdoor high performance dataloggers and controller devices for remote control and monitoring (i.e. IPEX12, IPEX16)
- MEGA: Irrigation systems coordinator: it manages, through different web services (i.e. SOAP, REST), the connections between all the management irrigation systems that implements the ISO 21622.
- Smart Agriculture: a web-based platform based on standards and open protocols (i.e. NGSI, MQTT) that has specific modules for the integration with IoT devices, data exploitation and map-based interfaces.

To make them compatible with DEMETER and to use their data and facilities they are paired with an appropriate entity (DEMETER Enabler) that will provide an AIM compliant wrapper. The central part of the figure above conforms the DEH through which all these entities are offered. On the left, we find DEMETER mandatory entities (grey) to be used by the optional ones (blue) needed by this pilot where we can find:

- Data storage: Component with all functionality related with database storage management.

- Crop status identification: This component estimates the crop status with data fusion and using parametric and machine learning techniques with different inputs (i.e. weather stations, IoT devices, imagery, etc.).
- Water consumption monitoring: This component will monitor real time water consumption of the irrigation system with the information from the remote controllers.
- Irrigation requirement estimation: This component will estimate the crop's irrigation needs with data fusion and using parametric and machine learning techniques with different inputs (i.e. weather stations, IoT devices, imagery, etc.).
- Machine learning and data exploitation: This component will offer machine learning and parametric techniques to be used for needed data exploitation, predictions, and information for the decision support system.

These enablers offered by the DEH are used to compose the DEMETER Enabled Applications for the business solutions of the pilot that are presented at the top of the figure:

- Irrigation Systems Coordinator
- Optimized cost & quality irrigation management application
- Real time monitoring and water supply control application
- DSS for irrigation

7.1.4 Issues identified in the Implementation Plan

Pilot 1.1&1.2 addresses summer crops, with the growing season beginning at April–May. Because DEMETER launched on September 2019, the planned start of Pilot Round 1 according to the proposal (M12, i.e., August 2020) is at the end of the growing season.

Due to covid-19 restrictions, it has been impossible to get ahead of the plan this year and to deploy the specific IoT controllers and actuators the pilot in Leon before the growing season. It will be tried to do so as soon as possible, but it is difficult in the middle of the growing season, because farmers are too busy. Therefore, the deployment might not be completed until the growing season ends, so there will be a delay of about 4 months.

This delay will affect the results provided by the deployment in Castilla & Leon region which will have also an impact on to *Deliverable 5.5: Overarching coordination, execution, evaluation, fertilisation and optimisation report for pilot round 1* (M20 – April 2021) and *Deliverable 5.6: Testbed, deployment, system extensions and applications for pilot round 2* (M23 – July 2021) since this information has to be provided just when the next growing season starts and it takes a few months to get this information. Nevertheless, this delay will not affect the other location in Cartagena Region whose information will be provided with no variation as estimated in the implementation plan.

8 Pilot 1.2 - Smart Energy Management in Irrigated & Arable Crops

The descriptions of the Pilots 1.1 and 1.2 have been merged in this document which now cover both water savings and energy management, since they involve the same stakeholders and solution approaches.

9 Pilot 1.3 - Smart Irrigation Service in Rice & Maize Cultivation

Pilot 1.3 aims to improve the management and automation of rice irrigation, along with nitrogen zonal fertilisation. Maize is also an important crop for rice growers, as it is included in the majority of crop rotation systems—at least once every three years. Therefore, the present pilot will also improve the management of both water and fertilisation in maize crop. The pilot will be deployed in one main site in Greece and in several locations around Central Macedonia regions:

- ELGO Experimental Station of approximately 50 ha at Kalochori area (40°37'4.41"N, 22°49'54.19"E), Thessaloniki, Greece. This will be dedicated to both rice and maize crops, where the smart irrigation system will be deployed, tested and validated.
- At least 10 farmers in the same area of Kalochori and another 10 farmers in other areas will be involved, in order to cover a variable rice and maize environment. These farmers will dedicate fields suitable for testing according to ELGO’s and ICCS’s plan.

This pilot will use as input a diverse set of data, coming from a specialised, in-field salinity and water height IoT sensor, meteorological stations, UAV-collected multispectral and thermal imagery, as well as satellite imagery (both Sentinel-2 and commercial very-high-resolution images).

For Pilot Round 1, Pilot 1.3 focused on setting up and testing prototypes of the envisioned services, in order to apply the necessary updates and integration with DEMETER. As such, the services were deployed in ELGO’s facilities (Kalochori Station for rice and Thermi Station for maize) within the context of small- and medium-sized controlled experiments, in close collaboration with an affiliated small group of farmers. Full provision of the services on an operational mode to other farmers will be performed in the second Pilot Round, which will span the 2021 and 2022 growing seasons (the growing season is approximately from May to October for rice and from April to September for Maize).

9.1.1 Use Case Workflow

Pilot 1.3 is mainly composed of following three interlinked services:

- Smart Irrigation Service for Rice (SIS-Rice): It provides support for optimal irrigation in rice crops, primarily using data provided by an in-field IoT sensor that measures water height and salinity. In addition, the use of satellite data will be tested, in order to provide indirect estimations on nearby fields that will not have an IoT sensor installed in them, using as reference a field with an IoT sensor installed in it. Weather forecast information is also used as input, to fine-tune the irrigation recommendations. All data is processed and stored on cloud service and RESTful web APIs are used to automatically control the electrical input (for irrigation) and output (for drainage) valves on the field, as well as to inform the end-user (farmer).

- Smart Irrigation Service for Maize (SIS-Maize): It provides support for optimal irrigation in maize crops throughout the cultivation period. It employs machine learning techniques for modelling the crop's irrigation requirements, based on appropriate indices calculated from UAV-collected thermal and multispectral imagery. This service produces irrigation needs maps for each field, with possibly different homogeneous subregions defined for each field. Alternatively, the use of satellite imagery will be used in the course of DEMETER, in order to cover larger areas. Weather forecast data are also used as input, to fine-tune the irrigation recommendations.
- Fertilisation Advisory Service for Rice & Maize (FertiRM): It provides prescription maps for nitrogen fertilisation in rice and maize crops. The analysis is based on UAV-collected (or satellite-collected if very high-resolution imagery is available) multispectral imagery, acquired at key stages of the cultivation's growth circle. Advanced machine learning techniques are employed for identifying nitrogen-stressed sub-regions within each field. The service provides spatially variable nitrogen prescription maps, in order to support variable rate application (VRA) techniques with specialised spreaders.

These services will be integrated into the DEMETER platform through Pilot's 1.3 BSE. The DEMETER Enablers will ensure the secure exchange of data, the interchange mechanisms for the data and the semantic interoperability of the various sensors and systems by using the AIM format (defined in D2.1) and translating all other data (as provided by the sensors) to this format. In addition, advanced Enablers, such as data visualization software, will use the datasets produced by the analysis services to graph them in appropriate widgets and deliver them to the end users (farmers). Care will be taken to interoperate with the existing hardware (e.g. the existing electrical water valves receive instructions as structured SMS messages; but we will also explore the upgrade of this system to a more modern communication format). Figure 7 presents a schematic overview of the flow of information within Pilot 1.3.

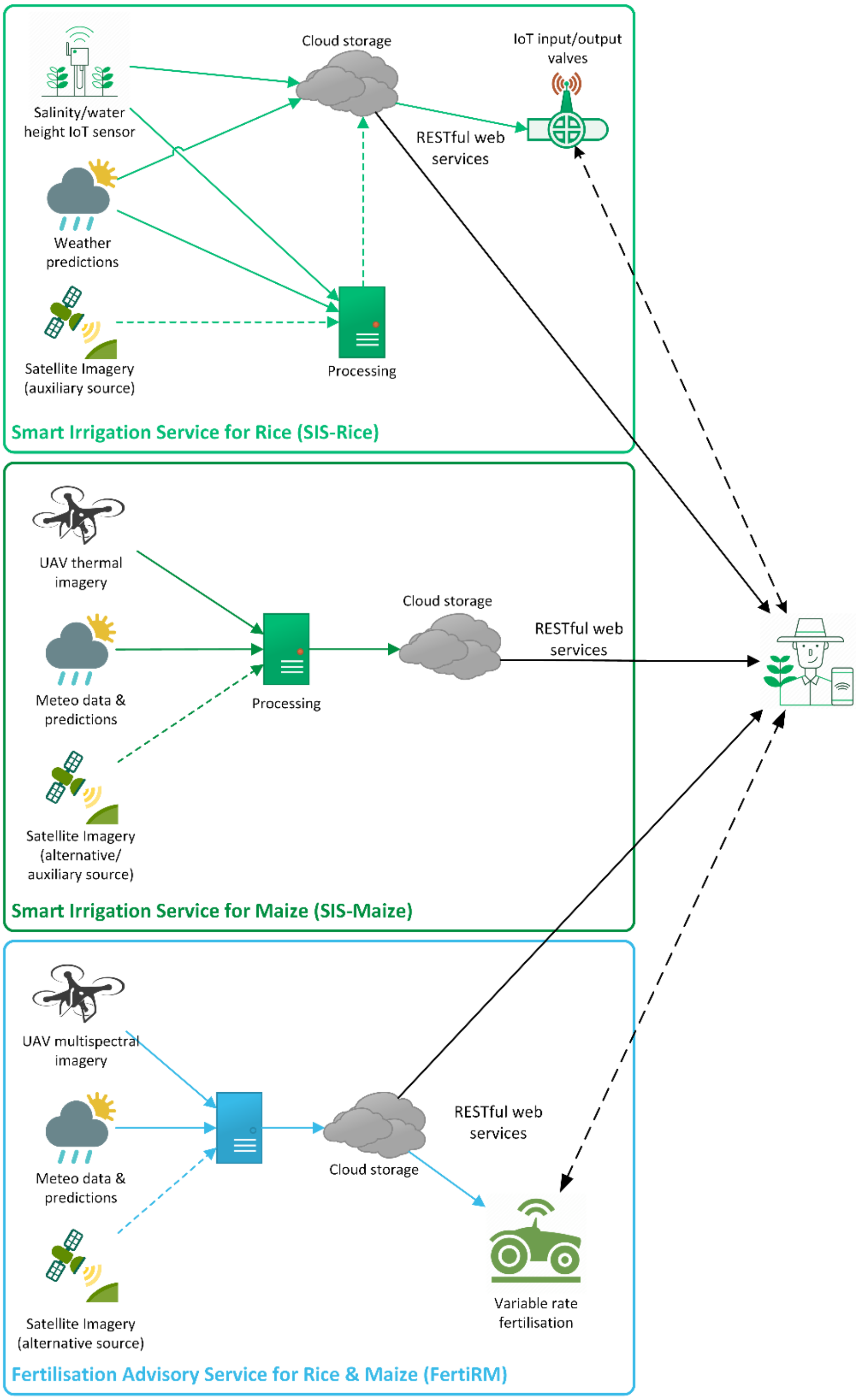


Figure 7: Overview of information flow for Pilot 1.3 and integration within DEMETER

The technical specifications for each of the services provided in this figure is described in Annex 3 – Technical specification provided by specific pilot.

9.1.2 Used Data

Collectively, the pilot's services will map data from:

- Geospatial data: location, farm boundaries
- Satellite imagery: Copernicus Sentinel-2 (to be investigated in DEMETER), PlanetScope multispectral imagery from Planet (to be investigated/tested in DEMETER)
- Meteorological data: air temperature, air humidity, solar radiation, rainfall
- Meteorological forecasts: air temperature, rainfall
- Water data: salinity (only for rice, via the specialized IoT sensor), water height (only for rice, via the specialized IoT sensor), water consumption
- Farm data: historical yield statistics, farm crop data

It will also use data from registered users:

- User credentials: username, password
- User general information: first name, surname, phone number, email address, home address
- User company information: company, sectors of interest

The DEMETER Enablers will ensure the secure exchange of data, the interchange mechanisms and the semantic interoperability by guaranteeing the AIM format. In particular, personal information, user credentials and geospatial information (location, farm boundaries, crop-specific information) will be directly modelled according to AIM, as defined in D2.1. Information from IoT sensors and weather station will be modelled via AIM-compliant wrappers. Information provided by remote sensing imagery will be processed internally in Pilot 1.3 and will be output in CSV format, which will be ultimately integrated into the AIM thanks to the reuse of specific ontologies related to agriculture features, crops, alerts, properties and systems.

Below we provide two brief examples of the use of the AIM concepts in the context of pilot 1.3:

- Farm data example:

```
{
    "@context": [
         "https://w3id.org/demeter/agri-context.jsonld",
    ],
    "@id":"http://w3id.org/demeter/plot/1",
    "@type": "Plot",
    "hasGeometry": "Polygon((40.619107 22.822914, 40.617334 22.832324,
40.608583 22.832286, 40.608607 22.825262, 40.619107 22.822914))",
    "identifier": "ELGO Kalochori Experimental station",
    "area": "1",
    "cropSpecies": {"@id": "http://w3id.org/demeter/CropType/6",
                    "@type": "CropType",
                    "name": "Rice",
                    "family": " Poaceae",
                    "description": " Oryza sativa, commonly known as Asian
rice, is the plant species most commonly referred to in English as rice.",
                    "species": "Oryza Sativa",
                    "agroVocConcept": http://aims.fao.org/aos/agrovoc/c_5438
                    "production": {
                                productionAmount: "230 tonnes"
                     }
            }
}
```

- Meteo data example:

```
{
    "@context": [
        "https://w3id.org/demeter/agri-context.jsonld",
    ],
    "@id":"http://w3id.org/demeter/measurement/5",
    "@type": "Measurement",
    "hasValue": "28.3",
    "isMeasureIn":<http://www.ontology-of-units-of-measure.org/resource/om-2/
degreeCelsius>,
    "relatesToProperty": <https://w3id.org/def/saref4agri#AirTemperature>,
    "measurementMadeBy": {"@id": "http://w3id.org/demeter/station/gr/2",
                    "@type": "WeatherStation",
                    "name": "ELGO Kalochori Ex Machine sensor",
                    "hasGeometry": "Point((40.617544 22.831559)"
            }
}
```

9.1.3 System Extensions and Applications

Figure 8 presents the mapping of pilot 1.3 to the DEMETER Reference Architecture, outlining the delivery of apps through it and the composition of such apps from DEMETER enabled entities, data and services. The raw resources (e.g. various types of devices) are presented at the bottom. They are connected through the appropriate communication protocols to existing services and systems, which have been described in the previous subsection. In order to make them compatible with DEMETER and use their data and facilities, they are paired with an appropriate entity (DEMETER Enabler) that will provide an AIM compliant wrapper.

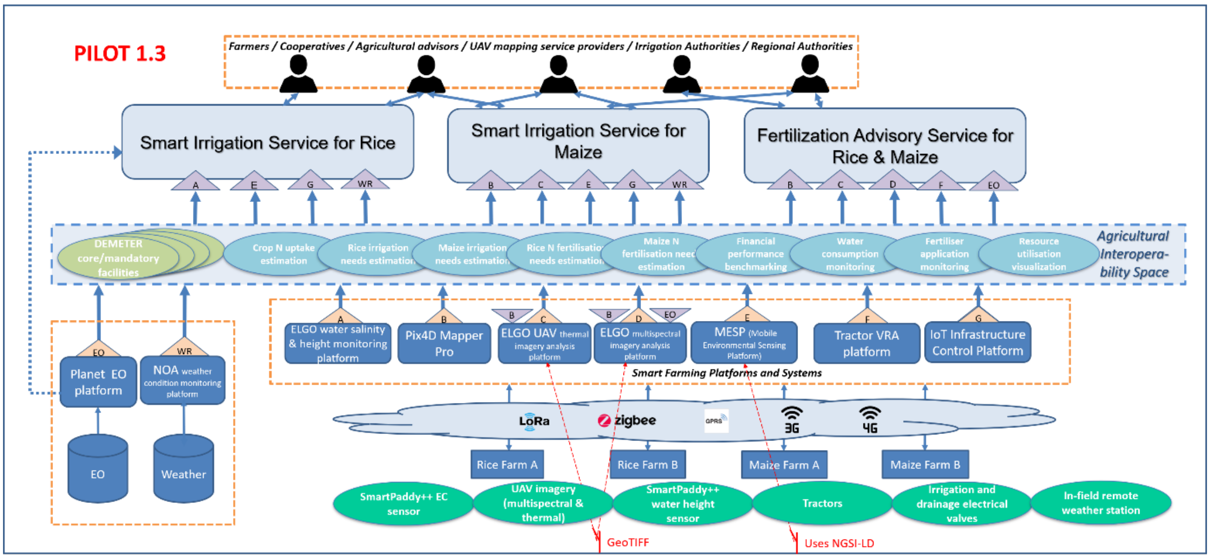


Figure 8: Reference architecture instantiated for Pilot 1.3

The central part of the figure above shows the DEH, through which all these entities are offered. On the left side, we find DEMETER mandatory entities (olive green) to be used by the optional ones (blue) needed by this pilot where we can find:

- Rice irrigation needs estimation (ELGO & ICCS): This component estimates the irrigation requirements in rice crops with data provided by the specialised IoT sensor, as well as with data fusion and parametric machine learning techniques for indirect estimation via satellite imagery and weather data regarding rainfall.
- Maize irrigation needs estimation (ELGO & ICCS): This component estimates the irrigation requirements in maize crops with data fusion and parametric machine learning techniques with different inputs (UAV thermal imagery, multispectral satellite imagery, weather data/predictions, etc.).
- Crop N uptake estimation (ELGO): This component estimates the current plants' uptake of nitrogen with parametric machine learning techniques using UAV or satellite multispectral imagery, which is the key parameter for estimating fertilisation needs.
- Maize/Rice N fertilisation needs estimation: These components estimate the fertilisation requirements, based on the N uptake estimations and trained machine learning models.
- Water consumption monitoring: This component will monitor real time water consumption of the irrigation system with the information from the remote controllers.
- Financial performance benchmarking; Resource utilisation visualisation: These components provide basic visualisation and performance indicators facilities to end-users.

These enablers offered by the DEH are used to compose the DEMETER Enabled Applications for the business solutions of the pilot that are presented at the top of Figure 8:

- Smart Irrigation Service for Rice
- Smart Irrigation Service for Maize
- Fertilisation Advisory Service for Rice & Maize

10 Pilot 1.4 - IoT Corn Management & Decision Support Platform

Pilot 1.4 aims to help farmers who want to rationalize their production costs and to get high yields. Rationalization of costs can be done by planting crops with different densities depending on soil nutrients, by distributing fertilizer at a variable rate and by acting in time, based on warnings triggered by high probability of disease, pests or extreme weather events.

The input that will be used consists of data from the sensors of agro-meteorological stations that are mounted in 15 agricultural farms in Romania, phenological data transmitted through a mobile application and satellite images.

Deliverables to farmers will consist of cartographic input distribution plans, compatible with the GPS of the agricultural machine, and warnings of diseases or pests, when humidity, temperature and other factors reach different thresholds.

10.1.1 Use Case Workflow

Pilot 1.4 uses as inputs such as soil and weather information provided by ground sensors and weather stations or as satellite images and the different indices they offer among others. The figure below presents a general picture of how this information is gathered through the different platforms (INOVAGRIA, DEMETER Services, weather station services), tailored to DEMETER Enhanced Entities (DEEs), and integrated into the DEH.

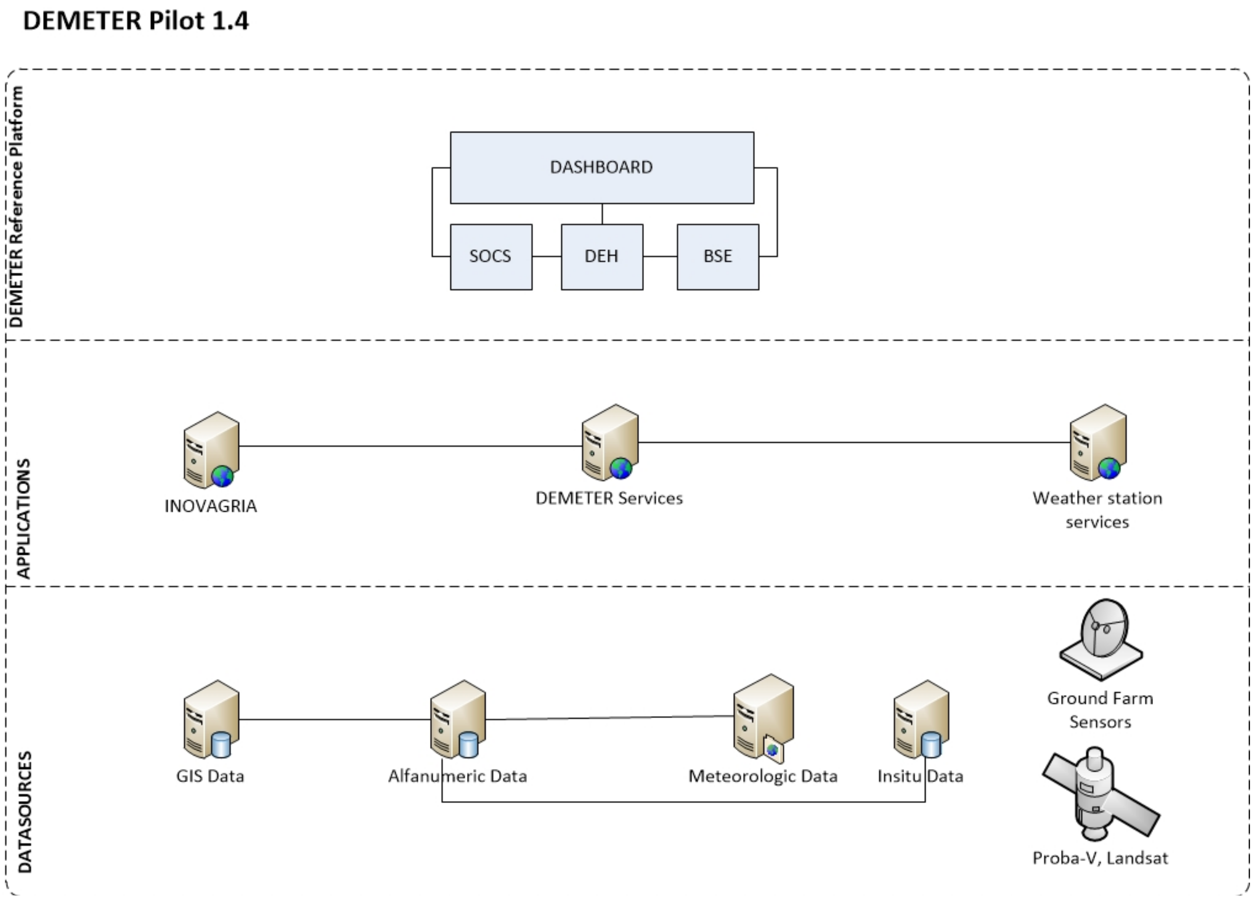


Figure 9: Pilot 1.4 integrated in the DEMETER platform

Sample use case – Plant Stress Detection

In Pilot 1.4 the Plant Stress Detection feature is implemented as below. Other features like Irrigation Management, Fertilisation Management etc. have similar use case workflows.

Scenario: Farmer wants to know plant stress percent and localization of affected areas.

What: Plant stress can come from many causes such as burns (very high temperatures), lack of water, lack of nutrients in the soil, etc. In this case, as a modern method of determining plant problems, the composition of the NDVI vegetation plan can be used.

Input: Farm data (geographic coordinates), crop traits, used inputs, used hybrid, seeding density, soil texture, soil moisture, agrometeorological data (temperature, rainfall, leaf wetness), in-situ determination (such as Chlorophyll meter), satellite images (Proba – V, Sentinel, Landsat). NDVI index correlated with the in-situ measurements for obtaining a viable modern method to use based on satellite images. The transmission of data from the field will be done through a custom application available to farmers.

Output: The main output will consist of recommendations for the distribution of important material for saving crops or even replanting certain areas of the plot.
Recommendations can also be in the form of warnings based on agrometeorological sensors or cartographic input distribution plans.

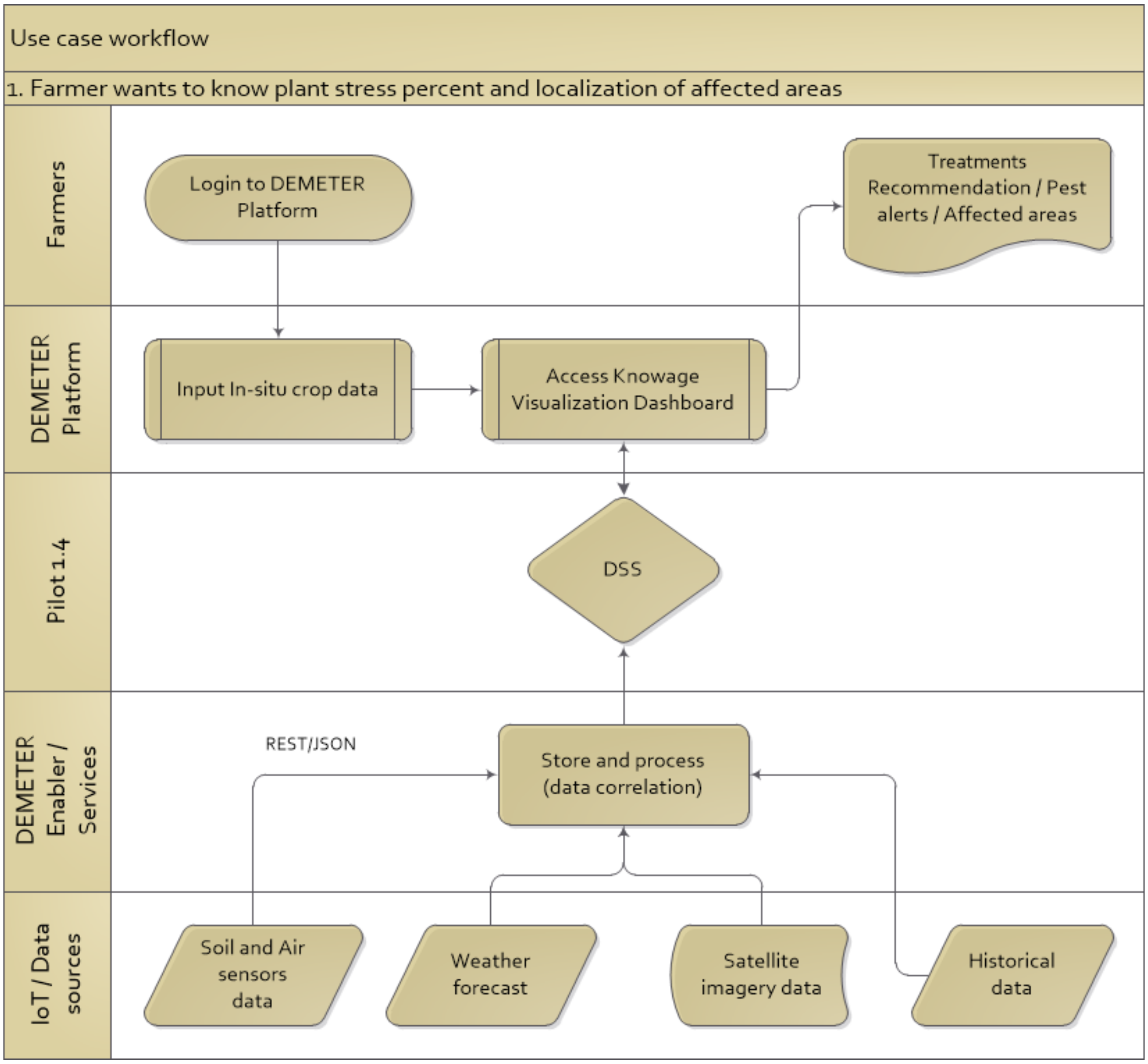


Figure 10: Pilot 1.4 - Plant stress detection use case workflow

10.1.2 Used Data

Pilot 1.4 is aiming at the optimisation of inputs, water and energy resources for maize crops. For this reason, the data it manages cover the following aspects:

- Geospatial data: Location, Geographical Information System (GIS), EGNSS (Galileo/GLONASS/ GPS)

- Satellite imagery: Landsat 7, Sentinel 2, Proba-V (RGB, NDVI)
- Climate data: Historical meteorological data and forecast
- Agrometeorological data: air temperature, air humidity, wind speed, wind direction, rainfall, soil temperature, soil humidity
- In situ data: Farm crop - phenological phase, plant height, degree of plant development.

Here is a sample of agrometeorological data from a weather station in JSON format:

```
"sensors": [
    {
        "name": "Precipitation",
        "current_value": "0.0",
        "unit": "l/m²"
    },
    {
        "name": "Air temperature",
        "current_value": "25.60",
        "unit": "C"
    },
    {
        "name": "Soil temperature -
6cm",
        "current_value": "26.70",
        "unit": "C"
    },
    {
        "name": "Humidity",
        "current_value": "100",
        "unit": "%"
    },
    {
        "name": "Air pressure",
        "current_value": "1004.8",
        "unit": "hPa"
    },
    {
        "name": "Battery",
        "current_value": "6540.0",
        "unit": "mV"
    },
    {
        "name": "Wind speed",
        "current_value": "0.0",
        "unit": "m/s"
    },

    {
        "name": "Air temperature 0cm",
        "current_value": "25.60",
        "unit": "C"
    },
    {
        "name": "Soil temperature -
12cm",
        "current_value": "26.70",
        "unit": "C"
    },
    {
        "name": "Field capacity",
        "current_value": "84.2",
        "unit": "%"
    }
],

"sensors_daily": [],
"sensors_daily_start_from": 1594846800,
"last_communication": 1593625511000
```

The INOVAGRIA Pilot 1.4 data will be re-modelled using the AIM as defined in D2.1 through the AgriFood Data Model and the adoption of specific ontologies related to agriculture features, crops, alerts, properties and systems.

```
Farm data:
{
    "@context": [
         "https://siveco.ro/demeter/agri-context.jsonld",
    ],
    "@id":"http://siveco.ro/demeter/plot/",
    "@type": "Plot",
```

```
    "hasGeometry": "Polygon",
    "identifier": "Number",
    "area": "Number",
    "cropSpecies": {"@id": "http://siveco.ro/demeter/CropType/",
                    "@type": "CropType",
                    "name": "String" ,
                    "family": " String",
                    "description": "String",
                    "species": "String"
            }
}

Meteo data:
{
    "@context": [
         "https://siveco.ro/demeter/agri-context.jsonld",
    ],
    "@id":"http://siveco.ro/demeter/measurement/",
    "@type": "Measurement",
    "hasValue": "Number",
    "isMeasureIn":<http://www.ontology-of-units-of-measure.org/resource/om-
2/degreeCelsius>,
    "measurementMadeBy": {"@id": "http://siveco.ro/demeter/station/",
                    "@type": "WeatherStation",
                    "name": "String" ,
                    "hasGeometry": "POINT"
            }
}
```

10.1.3 System Extensions and Applications

The solution, in which the DEMETER Pilot 1.4 is based on, is called INOVAGRIA.

INOVAGRIA is a software application designed to improve the lives of farmers, regardless of the size of the farm they own. Structured on several components and functionalities extremely useful for farmers, INOVAGRIA can answer the most important problems they face today: submitting applications for crop and animal subsidies, land lease management, management of agricultural works, animal register, etc. INOVAGRIA offers control and stability in an area where forecasts are the most difficult to achieve.

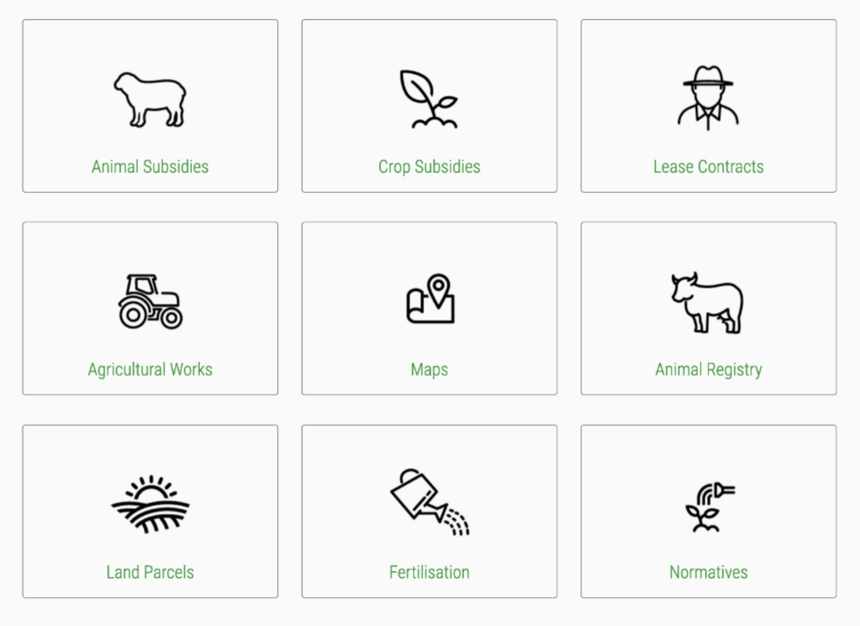


Figure 11: INOVAGRIA features

The following figure depicts the INOVAGRIA and DEMETER Pilot 1.4 integrated architecture diagram:

DEMETER Pilot 1.4

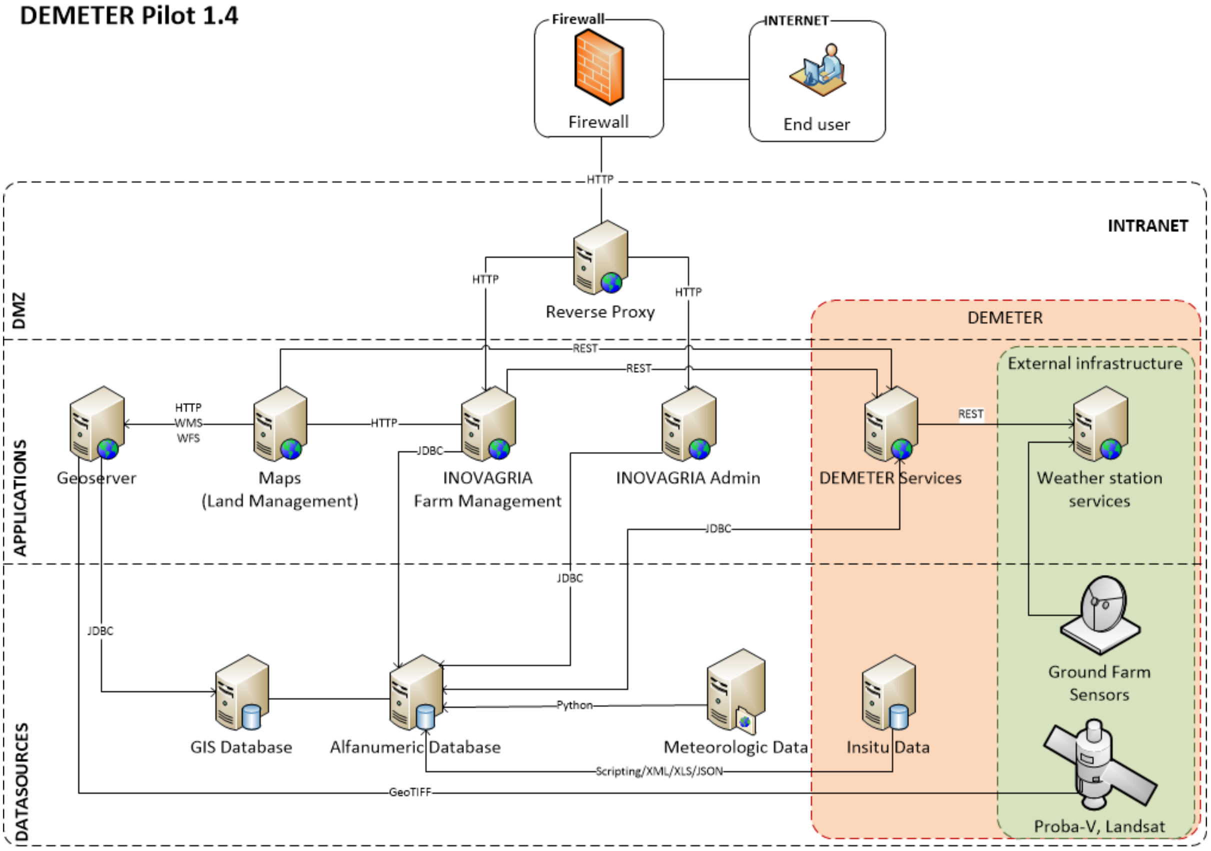


Figure 12: INOVAGRIA and DEMETER Pilot 1.4 integrated architecture diagram

Pilot 1.4 will be integrated in the DEMETER environment, according to the Reference Architecture, including all DEMETER components are required, and what sort of integration should be used for this specific pilot in terms of: customization of SW/HW external to DEMETER, applications, interfaces, as well as the customization/extension of the DEMETER enablers is necessary for a specific site of each pilot.

The image below represents Reference Architecture defined in DEMETER for Pilot 1.4:

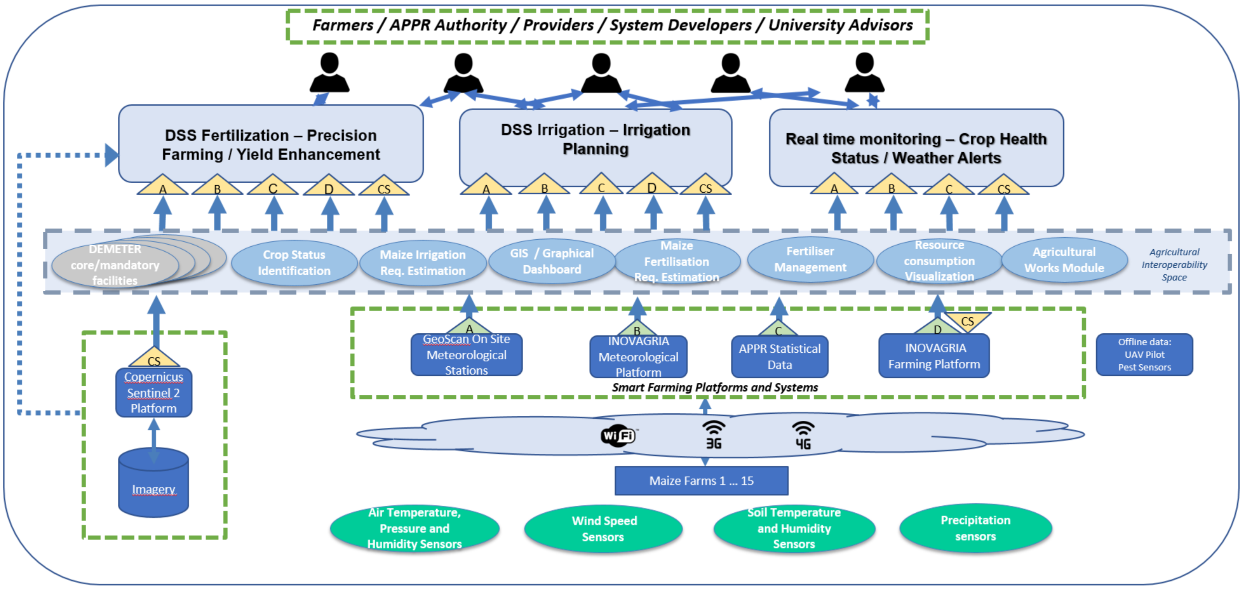


Figure 13: Reference architecture instantiated for Pilot 1.4

The Decision Support System of Pilot 1.4 is presented in the next image and is used to provide the following DEH components:

- Nutrition Management - Nitrogen Balance Model: A component that estimates crop nitrogen needs and the crop fertilization scheduling during the season to optimize nitrogen fertilization, avoiding nitrogen excess.
- Nutrition Management - Nutrient Monitor: A component for nutrient monitoring. The analysis will be made based on the layers with nutrients following the agricultural mapping of the soil, correlated with the satellite images and the obtained production plans.
- Crop Growth, Status and Yield - Plant Stress Detection: This component determines plant problems, plant stress can come from many causes such as: burns (very high temperatures), lack of water, lack of nutrients in the soil, etc.
- Irrigation Management: This component describes a crop water balance model that estimates crop soil moisture and the irrigation requirements of crops.

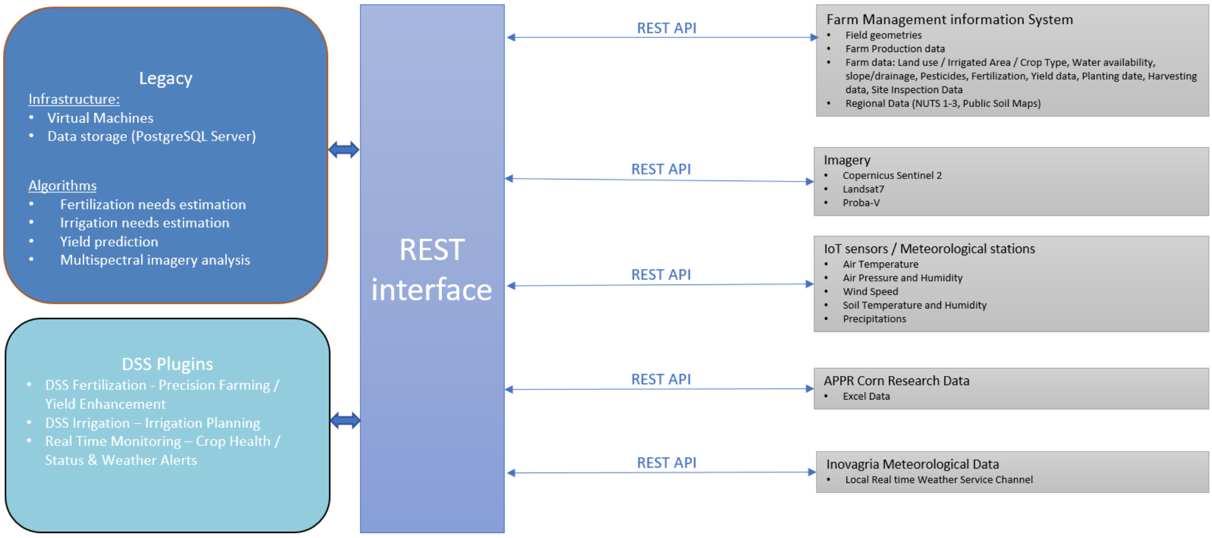


Figure 14: Decision Support System of Pilot 1.4

11 Pilot 2.1 - In-Service Condition Monitoring of Agricultural Machinery

This pilot aims at demonstrating the potential application of onboard sensors for in-service monitoring, as well as testing the legal applicability of existing after treatment (AT) sensors as alternative to Portable Emission Measurement Systems (PEMS) while considering aspects of data management. The Pilot will be deployed in two sites in Germany.

11.1.1 Use Case Workflow

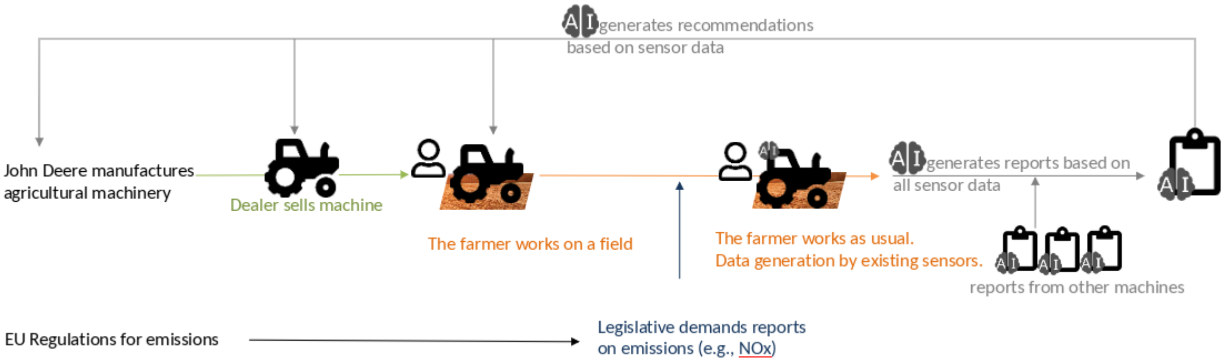


Figure 15: Overview of the main activities of this use case

This graphic provides an overview of the main activities of this use case showing the target situation that will be developed in DEMETER. Additionally, this diagram sketches how the data will be created, collected and processed. The sensor data from CAN-Bus will be monitored afterwards and based on past reports, legislative reports and data analysis, recommendations will be given to the farmer/dealer. At first data will be logged via a CAN Logger and extracted manually from the SD card. The data will be in the “mdf” format type (specifically “.mf4”). This format will be used for the analysis as well as for the data quality assessment, meaning that the pilot will make use of DEMETER components. Since this is the only pilot focusing on emissions or engines in general it is still under discussion how the pilot can provide a most useful link back to the DEMETER environment.

11.1.2 Used Data

The data used in this pilot will be from the machine on the one hand and from legislative regulations on the other hand. Data from the machine or to be more specific from the engine and the aftertreatment system will be monitored and analysed.

Data which will be collected for the purpose of development work:

- Fuel consumption: Base Fuelling Time
- Main Timing: Intake as well as Exhaust Mass Flows, Engine Speed, Rail-pressure, Actuator positions
- Pressures in engine and after treatment system: Barometric Pressure, DPF Delta Pressure, Oil Pressure
- Temperatures in engine and after treatment system: Coolant Temperature, DOC Outlet Temperature, DPF Outlet Temperature, EGR Gas Temperature, Engine Temperature, Fuel Temperature, Oil Temperature
- General Engine Data: Current Engine Control Mode, Current Indicated Torque, Desired Torque, Current Total Engine Operation Time, Diluent Air Ratio, DPF Soot Load, EGR Valve Area, Engine Operation Condition, Relative Humidity, Specific Humidity, Percent Load, Fresh Air Flow, Fresh Air to Fuel Ratio
- Emission Data: DPF Outlet NOx, DPF Outlet O2, SCR Outlet NOx, SCR Outlet O2, NH3 Flow Rate, Serial number, Service intervals, Operating hours, Diagnostic trouble codes

During this first round we have identified two possible mapping to the AIM, more specifically with the *agriIntervention*[2] and the *agriProduct* feature.

As stated in the Foodie[3] ontology description, ***Intervention****: represent the basic feature type for any application with explicitly defined geometry,* comprising properties: *type* (free text (e.g., tillage, pruning)[9]); *description*; *notes* (user-defined); *status* (free text); *creationDate* (in the KB); *interventionStart/End* (when started/ended in the real word); *interventionGeometry* (spatial extent); supervisor (entity with authority to guarantee its execution); operator (person who executed it); *evidenceParty* (entity who added it in the KB); *price*. This could fit to the operations that are stored in the shape files (we have there the geometry, the date, the tractor id, the timestamp)

Regarding the AIM "agriproduct", we could take advantage of its features not only to identify the product by its name, but also to provide more information about it (from the metadata and from the shapefiles).

---

[2] Gitlab DEMETER link: https://gitlab.com/demeterproject/wp2/agriculturalinformationmodel/domainspecificontologies/-/blob/master/agriIntervention.ttl

[3] https://foodie-cloud.github.io/model/FOODIE.html

11.1.3 System Extensions and Applications

In this section we are describing how this pilot is integrated into the DEMETER environment, including which DEMETER components are required, and what sort of integration should be carried for this specific pilot in terms of, customization of SW/HW external to DEMETER, applications, interfaces, as well as the customisation/extension of the DEMETER enablers is necessary for a specific site of each pilot.

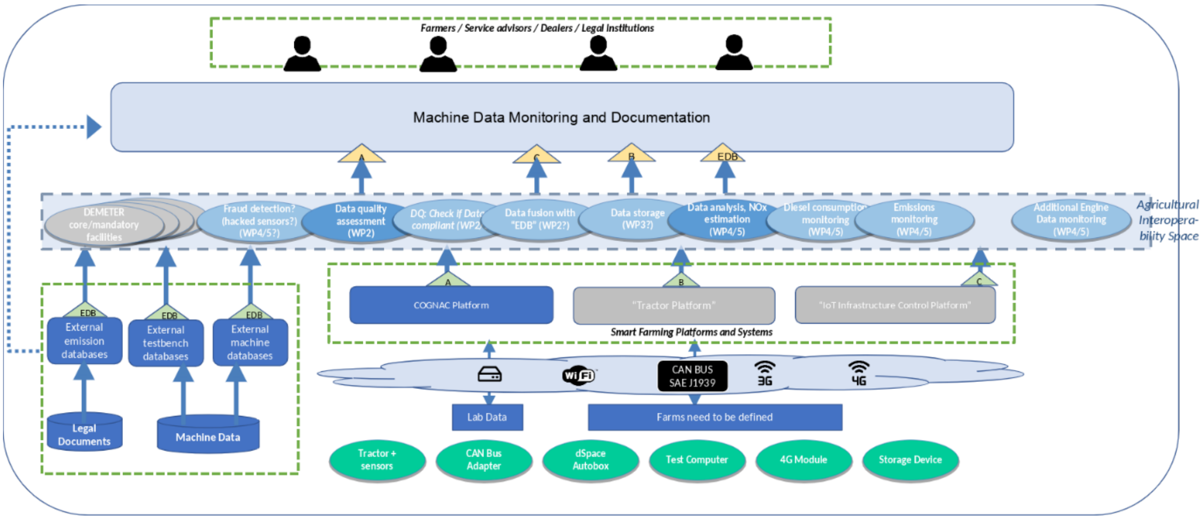


Figure 16: Instance of DEMETER reference architecture for the pilot

This figure presents a view of the DEMETER architecture of the pilot as it pertains to the delivery of apps through it and the composition of such apps from DEMETER enabled entities, data and services.

The raw resources are presented at the bottom. They are not connected to existing Farming Management Information Systems (FMIS) or IoT Device Platforms yet. In this pilot, we add to the DEMETER context the following hardware (besides the use of tractors):

- CAN Bus logger
- Storage device (SD card)

The data produced by the CAN Bus logger will be stored on a SD card mounted at the machine of the farmer. The collected data will be transferred and analysed afterwards only in the pilot environment, i.e. local computer, due to data sharing and privacy constraints. Moreover, this data processing will make use of DEMETER components, mainly the WP2 component “Data quality assessment”, and will therefore be in alignment to DEMETER specifications.

At the top of the figure, the pilot specific DEMETER enabled application for the business solutions is presented: machine data monitoring and documentation. This pilot focuses specifically on emission data (NOx estimation) and will analyse and monitor the data to provide information to the stakeholders comparing the results also with existing regulations. Thereby, it would be possible to make use of suitable DEMETER analysis components.

As highlighted in the figure, the pilot will mainly make use of the DEMETER WP2 component “Data quality assessment” to assess the quality of the sensors data. This component will be also executed locally in the pilot environment and will be adjusted to assess the quality of ".mf4"-files. Furthermore, the pilot will provide requirements and needs regarding this component and the desired data quality assessment mechanisms to WP2 for further refinement and adaptations to our own pilot context. In other words, we will make use of data quality metrics addressing several data quality aspects defined by WP2 and we will extend this component by adjusting parts of these implementations to also assess those quality aspects in ".mf4" files and to provide new quality metrics fitting to our pilot 2.1 interests. With this integration into the DEMETER scope, both parties, i.e., pilot 2.1 and WP2, will benefit in a most useful way. Other DEMETER results could be integrated to further improve the development inside the pilot environment. A link back to DEMETER components will take place in terms of feedback, but without an automatic procedure of transferring data or results.

12 Pilot 2.2 - Automated Documentation of Arable Crop Farming Processes

This pilot develops an automated job identification and documentation for fertilization, tillage, seeding, and spraying application, as well as a job cost estimation for spraying and fertilization later that may also focus on prediction to support the farmers' decision in the field. It will include capturing high precision data, merging with data from farms / machines, and deriving required cost estimation and documentation parameters via data analytic and knowledge management techniques. Having a knowledge on job cost calculation allows farmers to make a better decision. Farmers can get knowledge for cost savings (reduced costs for fertilisation), and:

- Environmental benefits (e.g. improvements of the biodiversity, water quality);
- Cost savings for the farmer (reduced costs for fertilisation);
- Investments into farming activities.

12.1.1 Use Case Workflow

The following figure shows how the information flow traverse from the farmer in a traditional system. This process is improved, as Figure 18 presents, where different data processing phases are performed in order to estimate job costs. This is of utmost importance for farmers who desire to optimise their resources as explained below.

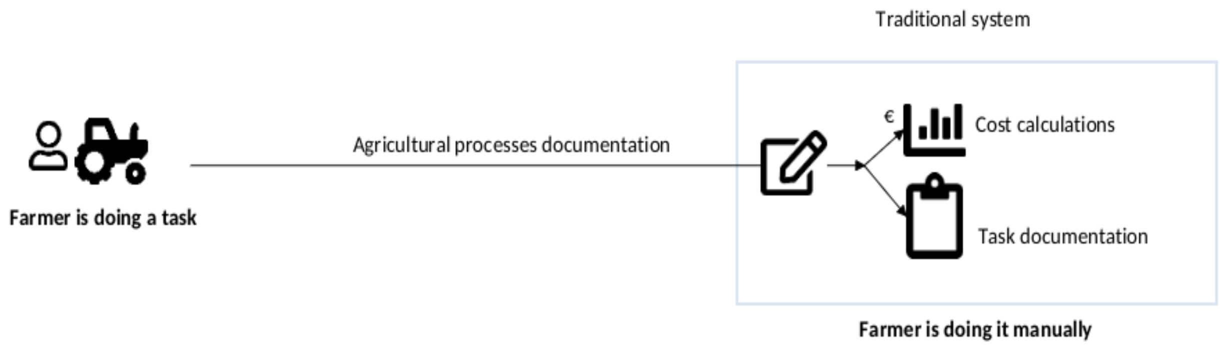


Figure 17: Pilot data flow before DEMETER

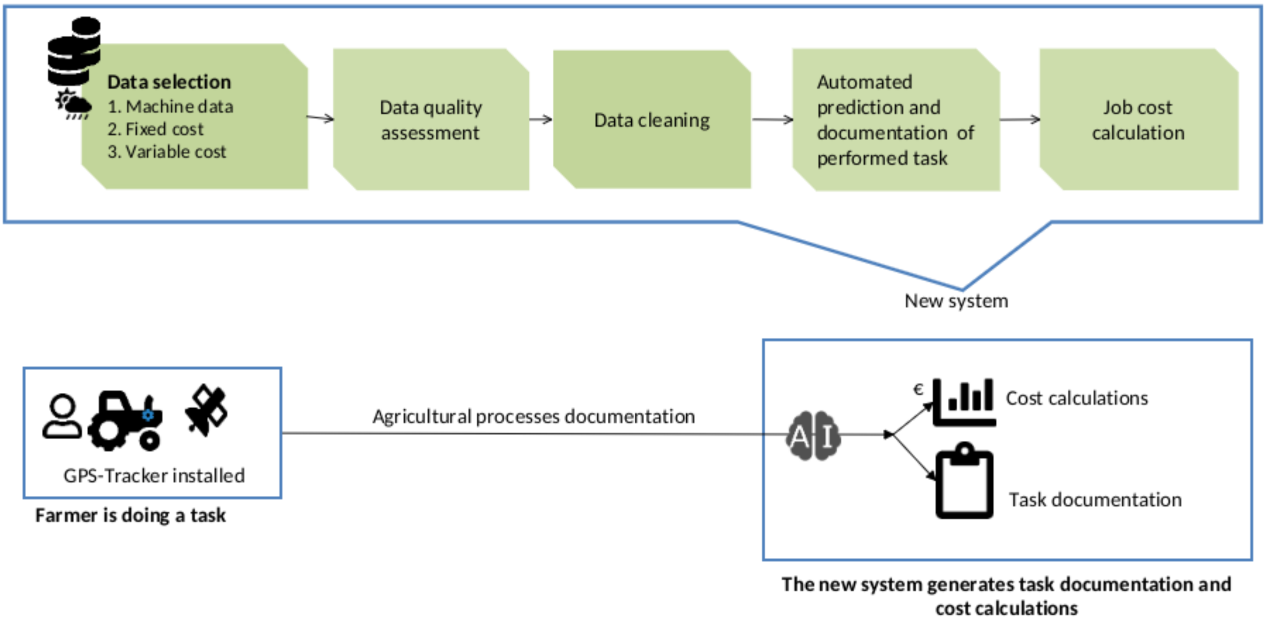


Figure 18: Pilot dataflow after DEMETER

For a farmer, measuring the success of decisions is fundamental to optimise these decisions in a future action. Likewise, measuring a sequence of the job costs helps the farmer to evaluate his decision within that sequence. Since the farmer uses advanced machinery technology in order to apply his decision in the field a vast amount of data is generated. This is expressed in the above figure by the flow from the farmer to the system. Such data contains location (latitude and longitude) and attribute information that represents information such as the name of the application, date, amount of applied rate, etc. This data is produced once the farmer performs an operation. The data is normally transmitted via a network to “My John Deere Operation Centre” that utilizes a cloud service. Afterwards the data will be available in ESRI shape file format.

Measuring job cost in agriculture is one of the challenging tasks for the farmer. Indeed, job cost calculation involves all the payments that are needed to make the crop yield available to the consumer as a product. Hence, measuring every single step in job cost calculation needs tremendous efforts and availability of respective information and prices. In addition, documentation of jobs type, cost, and details of operation is a difficult task in farming practices. Therefore, pilot 2.2. is building a concept for job cost calculation for fertilizing and spraying jobs including autonomous documentation to support the farmer’s decision in the field.

The pilot will make use of the DEMETER WP2 component “Data quality assessment” to assess the quality of the farm-operation data. This implementation of the pilot will analyse the used data focusing on the identified needs of the stakeholders involved, i.e. service providers. A report will be created containing the results of this data quality assessment that can be used by the other partners to better understand their own data and to address the identified issues (e.g., in the data collection procedure) in order to further increase the quality of their data-driven solutions. In that case, also the farmer will benefit from the “Data quality assessment” component.

12.1.2 Used Data

The pilot will map data from:

- Geospatial data: Location, Velocity, Movement patterns, GPS
- Farm data: Historical farm statistics, Farm crop data
- External data: Time / Season, Weather data, KTBL, myAgrar, KAACK-terminhandel

It will also use data from registered users:

- User credentials: Username, Password
- User general information: First name, Surname, Phone number, Email address

Data acquired from IoT devices will be saved in repositories as historical data, also with all that generated by its analysis to get different agro-indices.

This pilot works with similar information as described in the previous pilot, for this reason the mapping to the AIM, at this first round matches the same features as presented in Pilot 2.1 comprising both *agriIntervention* and *agriproduct*.

12.1.3 System Extensions and Applications

In this section we are describing how this pilot is integrated into the DEMETER environment, including which DEMETER components are required, and what sort of integration should be carried for this specific pilot in terms of, customization of SW/HW external to DEMETER, applications, interfaces, as well as the customisation/extension of the DEMETER enablers.

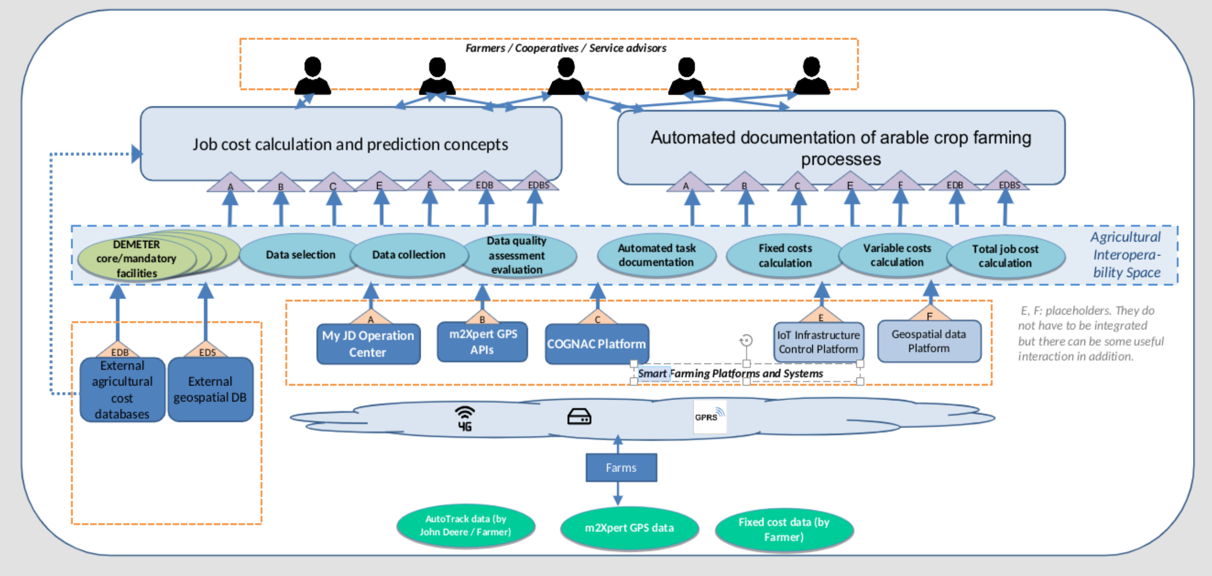


Figure 19: Instance of DEMETER Reference architecture of pilot 2.2

This figure presents a view of the DEMETER architecture of the pilot as it pertains to the delivery of apps through it and the composition of such apps from DEMETER enabled entities, data and services.

The raw resources are presented at the bottom. They are connected to existing Farming Management Information Systems (FMIS) such as My John Deere Operation Center and m2Xpert portal. In this pilot we can find:

- GPS tracker
- Autotrack data

The collected data is transferred and analysed afterwards only in the pilot environment, i.e. local computer, due to data sharing and privacy constraints.

The DEMETER Enabled Applications for the business solutions of the pilot that are presented at the top of the figure are:

- Job cost calculation and predictions concepts
- Automated documentation of arable crop farming processes

This pilot focuses specifically on operation data (fertilizing, spraying and co.) and will analyse and monitor the data to provide information to the stakeholders in order to facilitate the documentation of farming processes. Thereby, it would be possible to make use of suitable DEMETER analysis components.

As highlighted in the figure, the pilot will mainly make use of the DEMETER WP2 component “Data quality assessment” to assess the quality of the sensors data. This component will also be executed locally in the pilot environment. Other DEMETER results could be integrated to further improve the development inside the pilot environment. A link to DEMETER components will take place in terms of feedback, but without an automatic procedure of transferring data or results.

13 Pilot 2.3 - Data Brokerage Service and Decision Support System for Farm Management

Pilot 2.3 will establish a trust-based and compliant data market for agricultural enterprise data that sits between the owners and operators of agricultural data Clouds and the farmer, and that will include both a technical platform and advisory services that will ensure easy adoption of data and technology by farmers. The objective is to use data integration, analysis, and visualization applications for a decision support system. The Pilot will initially be deployed in 6 farms in the following countries:

- Czech Republic – 2 sites
- Poland– 2 sites
- Latvia – 1 site
- Norway – 1 site

They will implement them in the process of managing their farm, as well as indicate expectations and comments regarding the functionality of this system.

13.1.1 Use Case Workflow

Figure 20 provides an overview of the main activities of this use case showing the target situation that will be developed in DEMETER.

For this pilot, we have considered as inputs data which are presented on the left side of the picture. We have three main groups of inputs information which are used for this Data Brokerage Service for Decision Support System for Farm Management:

1. Data from exact, online and long-term measurements on the farm (example: data from meteorological stations, the sensor on the farms, …
2. External data specific to farm (example: satellite picture and information, external weather forecasts, …
3. Data from other sources used at the farm (example: governmental regulations, subsidy calculation, work planning information, …

These pieces of information are received by end-user (the farmer) by two possible ways which you can see in Figure 20 below.

The first is as independent information from each information source (this is the current situation and is not part of the DEMETER project).

The second (the DEMETER) way is all information from each information sources is gathered through the different IoT platforms, tailored to DEMETER Entities, and integrated into the DEMETER Hub. The information provided by IoT follows open standards-based protocols. This way, the information is translated into a richer representation format. The data is adjusted to a format that will describe all inputs in one application. This more effective utilization of this data provides support for the decision-making process. Visualizations with a combination of charts and Meteograms / multicharts for sensor and meteorological data will be developed. A mobile application will provide alarms and warnings with information about suitable / not suitable conditions for defined interventions.

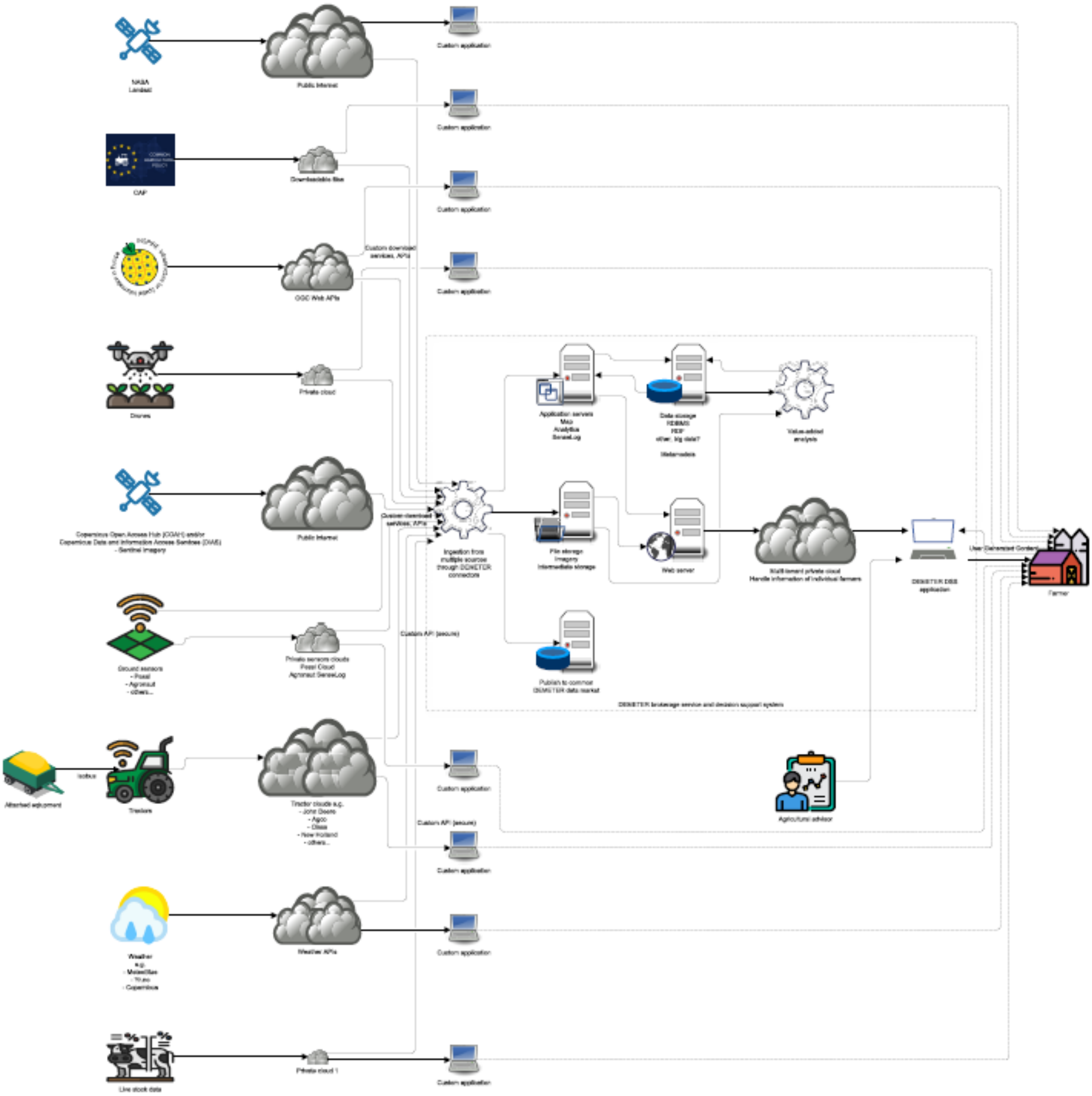


Figure 20: Example of pilot 2.3 flow of information

Details related to connectivity and networking infrastructures are provided in Annex 3 – Technical specification provided by specific pilot.

13.1.2 Used Data

This DEMETER pilot 2.3 aims to establish a trust-based and compliant data market for agricultural enterprise data that sits between the owners and operators of agricultural data clouds and the farmer, and that will include both a technical platform and advisory services that will ensure easy adoption of data and technology by farmers. For this reason, the data it manages cover the following data map created from:

- Geospatial data: Location, SigPac, EGNSS (GPS/EGNOS/Galileo)
- Satellite imagery: Copernicus Sentinel 2
- Climate data: Air temperature, Air humidity, Wind speed, Wind direction, Solar radiation, Rain
- Soil data: Temperature, Salinity, Humidity, Conductivity, Soil water tension, Soil water content, Soil water height
- Water data: Hydrants water flow, Water consumption
- Farm data: Historical farm statistics, Farm crop data

It will also use data from registered users:

- User credentials: Username, Password
- User general information: First name, Surname, Phone number, Email address, Home address
- User company information: Company, Sectors of interest, Other.

Additionally, this pilot receives and manages other general information such as data acquired from IoT devices which will also be saved in repositories as historical data, along with all data generated by its analysis to get different agro-indices.

This information is modelled thanks to the AIM already defined in D2.1 through the AgriFood Data Model. Information were also defined in D2.1 and integrated into the AIM thanks to the reuse of specific ontologies related to agriculture features, crops, alerts, properties and systems.

13.1.3 System Extensions and Applications

Figure 21 below describes to the instantiation of the Reference Architecture defined in DEMETER for Pilot 2.3. This figure presents the mapping of the DEMETER architecture to the pilot, the delivery of apps through it and the composition of such apps from DEMETER enabled entities, data and services.

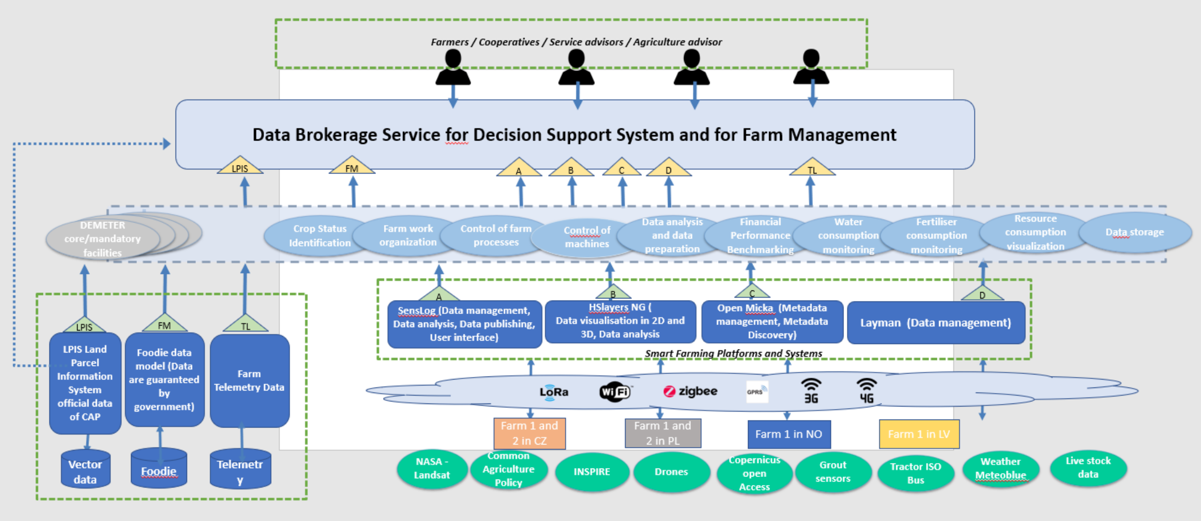


Figure 21: Reference architecture instantiated for Pilot 2.3

The raw resources (e.g. various types of devices) are presented at the bottom. They are connected through the appropriate communication protocols (LoRa, WiFi, etc.) to existing Farming Management Information Systems (FMIS) or IoT Device Platforms. In this pilot we can find:

- SensLog: is web-based sensor data management application. This component provides functionality for receiving, storing, pre-processing and publishing of sensor data. SensLog is suitable for numeric or textual sensor data from static in-situ or mobile sensors and is also suitable for storing Volunteered geographic information (VGI) with connected multimedia files.
- HSlayers NG[4]: is a web mapping library written in JavaScript. It extends OpenLayers 4 functionality and takes basic ideas from the previous HSlayers library but uses modern JS frameworks instead of ExtSJS 3 at the frontend and provides better adaptability. That’s why the NG (“Next Generation”) is added to its name. It is still under development and provided as open source. HSLayers is built in a modular way which enables the modules to be freely attached and removed as far as the dependencies for each of them are satisfied. The dependency checking is done automatically.
- (Open)Micka: is a Web application for management and discovery of (geo)spatial (meta)data. From a user perspective, it represents a cataloguing tool for searching and finding relevant resources, such as geospatial and non-geospatial datasets, web services, sensor measurements, map compositions, (traffic) models, documents, Web pages, reports, legislation or e-shop. The main goal of (Open)Micka is to connect all the relevant kinds of resources and provide answers.
- Layman: (API user interface through HS Layers NG), depends on GeoServer for easy management, access control and publishing of geodata, the LayMan server tool will be used. The server will enable publishing of geospatial data. The server offers REST API. Two models are available:
  - layer: visual representation of single vector dataset (i.e. ShapeFile or GeoJSON)
  - map: collection of layers

To make them compatible with DEMETER and to use their data and facilities they are paired with an appropriate entity (DEMETER Enabler) that will provide an Agricultural Information Model (AIM) compliant wrapper. The central part of the figure above conforms the DEH through which all these entities are offered. On the left we find DEMETER mandatory entities (grey) to be used by the optional ones (blue) needed by this pilot where we can find:

- Crop Status Identification
- Farm work organization
- Control of farm processes
- Control of machines
- Data analysis and data preparation
- Financial Performance Benchmarking
- Water consumption monitoring

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[4] HSlayers NG: https://ng.hslayers.org/

- Fertiliser consumption monitoring
- Resource consumption visualization
- Data storage

These enablers offered by the DEH are used to compose the DEMETER Enabled Applications for the business solutions of the pilot that are presented at the top of the figure:

- Data Brokerage Service for Decision Support System and for Farm Management

14 Pilot 2.4 - Benchmarking at Farm Level Decision Support System

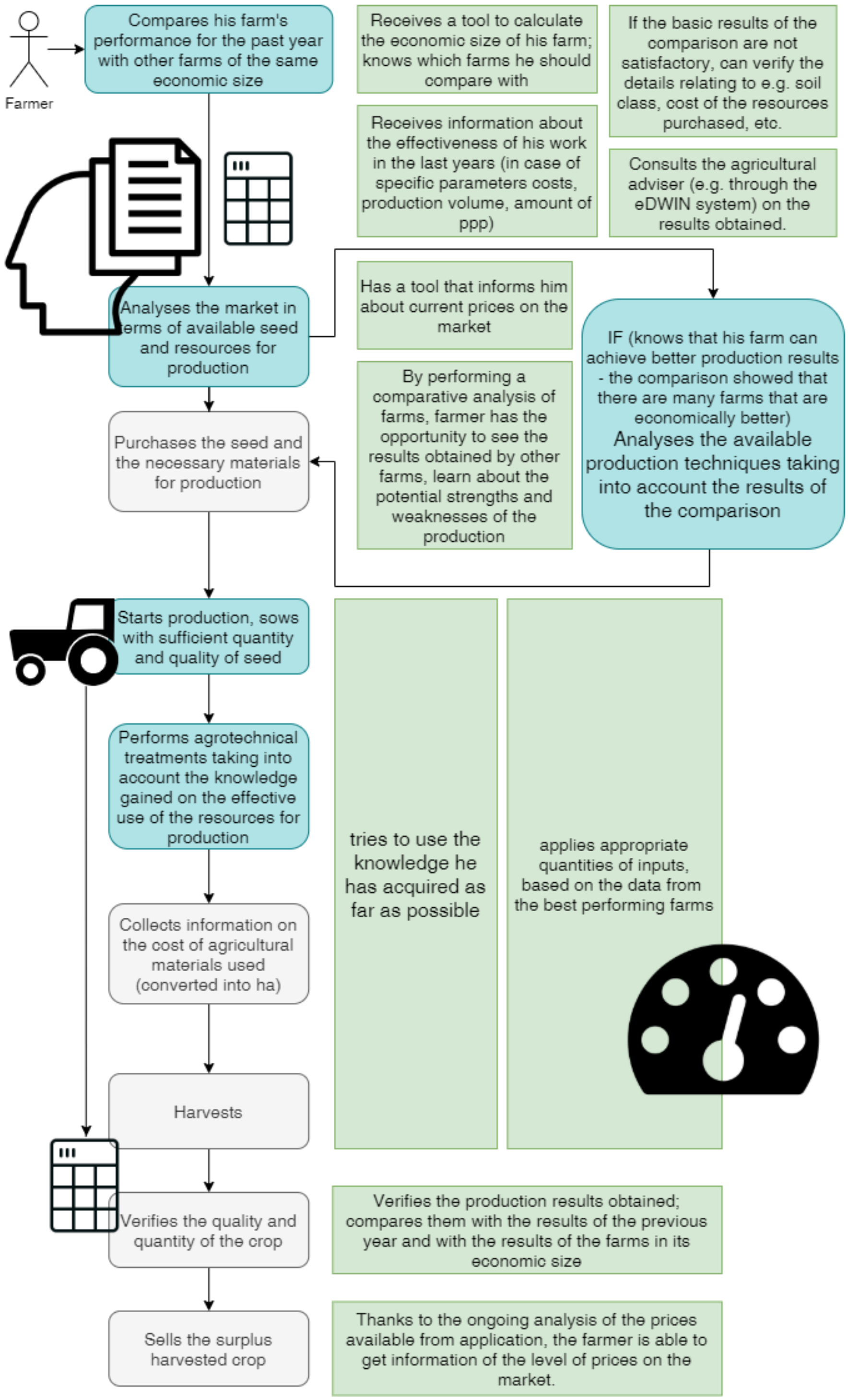
This pilot aims at developing services to support the benchmarking on the productivity and sustainability performance of the farms, leveraging and extending an existing decision support system for farmers (DSS). This will involve monitoring different conditions and parameters affecting such indicators, collecting the data and integrating it in a unified layer accessible by the DSS.

The Pilot will be deployed in 10 sites with different farms sizes:

- 5 small farms
- 3 medium farms
- 2 big farms

14.1.1 Use Case Workflow

Next figure shows a diagram describing the information flow for this pilot.



Compares his farm's performance for the past year with other farms of the same economic size

Receives a tool to calculate the economic size of his farm; knows which farms he should compare with

If the basic results of the comparison are not satisfactory, can verify the details relating to e.g. soil class, cost of the resources purchased, etc.

Receives information about the effectiveness of his work in the last years (in case of specific parameters costs, production volume, amount of ppp)

Consults the agricultural adviser (e.g. through the eDWIN system) on the results obtained.

Analyses the market in terms of available seed and resources for production

Has a tool that informs him about current prices on the market

IF (knows that his farm can achieve better production results - the comparison showed that there are many farms that are economically better)
Analyses the available production techniques taking into account the results of the comparison

Purchases the seed and the necessary materials for production

By performing a comparative analysis of farms, farmer has the opportunity to see the results obtained by other farms, learn about the potential strengths and weaknesses of the production

Starts production, sows with sufficient quantity and quality of seed

Performs agrotechnical treatments taking into account the knowledge gained on the effective use of the resources for production

tries to use the knowledge he has acquired as far as possible

applies appropriate quantities of inputs, based on the data from the best performing farms

Collects information on the cost of agricultural materials used (converted into ha)

Harvests

Verifies the quality and quantity of the crop

Verifies the production results obtained; compares them with the results of the previous year and with the results of the farms in its economic size

Sells the surplus harvested crop

Thanks to the ongoing analysis of the prices available from application, the farmer is able to get information of the level of prices on the market.

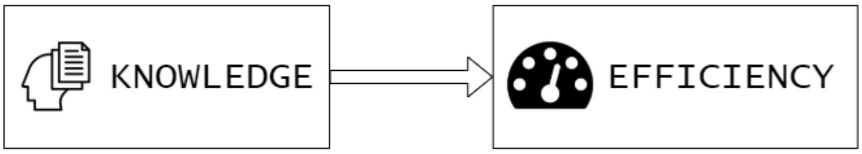


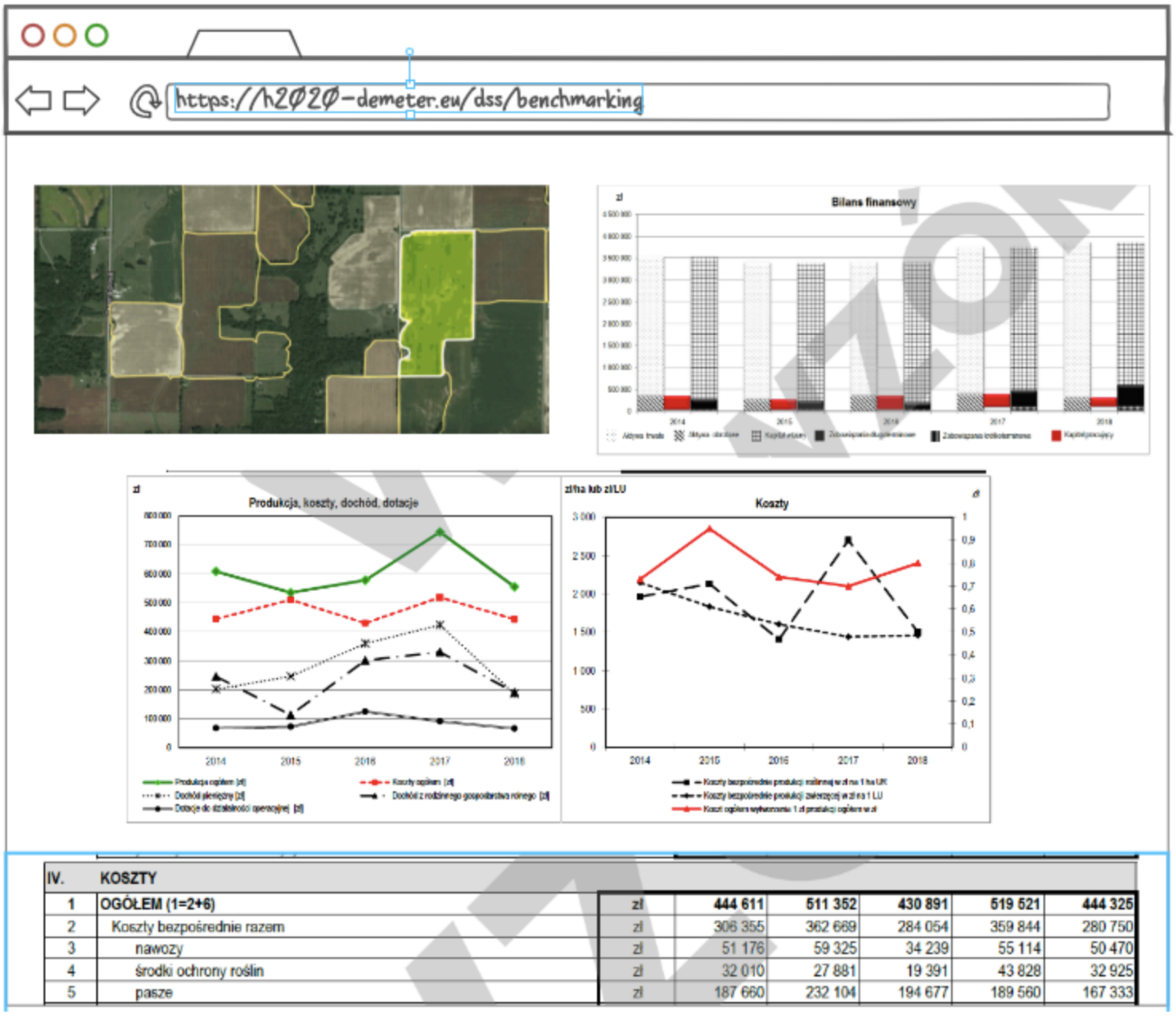
Figure 22: Diagram of information flow for Pilot 2.4

The target users have been divided into 3 groups and 3 different scenarios:

- A beginner farmer (not FADN, not VAT) browses FADN data in his type / size, without comparing: User enters the platform. Then he introduces the necessary data to determine the type of farming and economic size of his farm. In the next step, the system determines the type and economic size, which includes the given farm. Finally, the farmer can see the results of other farms in the type and size of his choice. In addition, the farmer can see the results in terms of economic and financial parameters of interest, e.g. wheat yield, cow yield, fertilization costs or agricultural income.
- An advanced user (not FADN, VAT) wants to verify / compare several parameters, e.g. yield, costs: Some time ago the user started using the application and viewing data on similar farms. Now the application has offered him the opportunity to enter his own data and thus compare himself in a specific group. The User wanted to check whether the crop from his crops is high or low and to be able to get this information in the application, he entered data on the corn crop in his fields for 2018 and 2019. The application saved these data, and he received the result in the form of a tabular comparison comparing his data with the average yield values on FADN farms and prices on the local and national market. He observed that his yield was lower. He noticed, however, that the graph and table present an additional value - precipitation in its location presented in averaged form for individual months of the year. He decided to analyse the situation, but he was still sure that his farm could prosper in the current weather conditions. Therefore, he decided to seek information from Adviser, which he could change or improve.
- FADN user wants to compare individual report with the group: The farmer receives an individual report on FADN accounting, he is specified in terms of the size and economic type of the farm. Thanks to these baseline data, he can compare with the data from the FADN Database, specifying exactly the parameters that the farmer would like to pay attention to (e.g. income, costs, productivity ...) Thanks to the compatibility of the database and the report, user can precisely compare the data.

The decision support system in the pilot 2.4 will be based on the eDWIN system designed under another project. Its main functionalities will be:

- Calculation of the economic size of the farm based on dedicated algorithms and instructions
- Presentation of graphs showing the current and historical state of affairs for farms of similar economic size
- Presentation of information on prices of agricultural products and agricultural materials needed for production in subsequent years; support for decision on the place of purchase (reference to the lowest or average market prices)



IV.	KOSZTY						
1	**OGÓŁEM (1=2+6)**	zł	**444 611**	**511 352**	**430 891**	**519 521**	**444 325**
2	Koszty bezpośrednie razem	zł	306 355	362 669	284 054	359 844	280 750
3	nawozy	zł	51 176	59 325	34 239	55 114	50 470
4	środki ochrony roślin	zł	32 010	27 881	19 391	43 828	32 925
5	pasze	zł	187 660	232 104	194 677	189 560	167 333

Figure 23: Model of the target application solution in the pilot

The next figure presents the architecture draft for the exchange of data between management system and farm management systems via the REST service. This data is available from external services as weather stations.

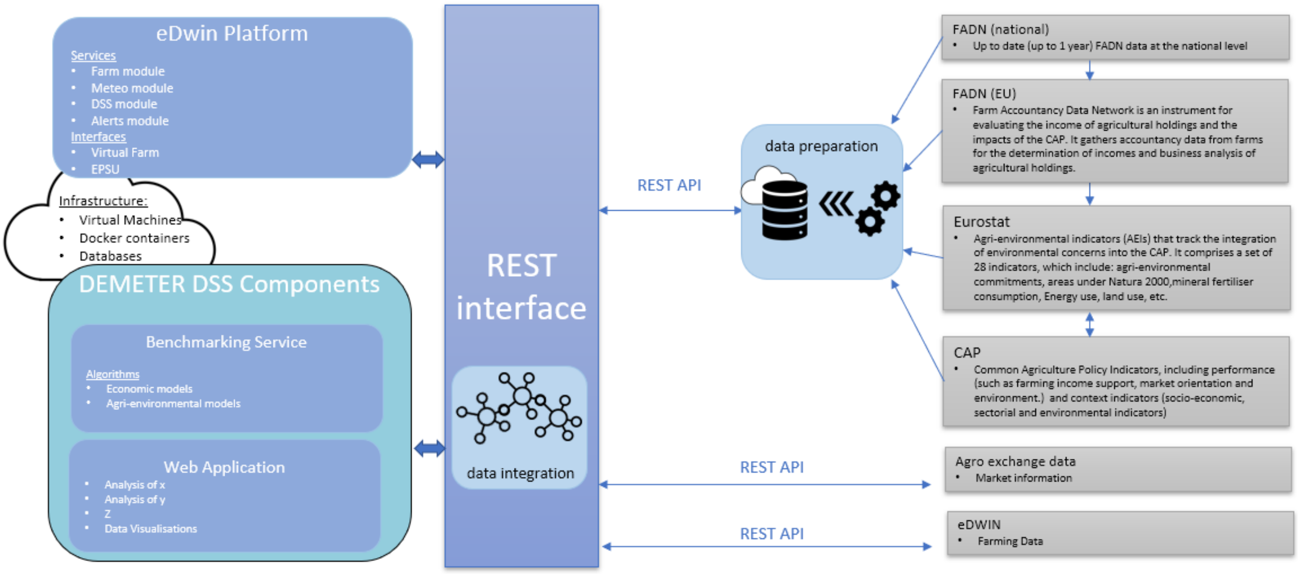


Figure 24: Overview – environment for algorithm development and web application front-end

14.1.2 Used Data

This pilot aims to benchmark farms based on the data collected by the Polish and European FADN and to support farm decisions on the basis of results of benchmarking and other data listed below:

- FADN (Farm Accountancy Data Network) – statistics on agricultural holdings in Europe. Include information on the volume of production, quantity of production materials used, farm profits, etc.; the economic size of farm will be calculated on the basis of these data.
- Eurostat – agri-environmental indicators linked dataset generated following the process from Eurostat GitHub project[5], and including links to other open EU datasets like NUTS (Nomenclature of Territorial Units for Statistics)
- Agromarket data – data on current agro-market prices for several categories; collected on an ongoing basis by Agricultural Advisory Centres; there data will be used to compare market prices in different areas and will assist in purchasing decisions, and will also support possible negotiations
- Weather data – air temperature, air humidity, wind spend, wind direction, rain (historical data) data that can be used as complement to economic statistics (the algorithms should include favourable weather conditions as a factor for better production performance in comparisons/benchmarking process)
- Farm/field data – location of fields, economic data, results of production, the materials used as fertilisers or plant protection products (reference to prices on the markers), local weather data

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[5] https://github.com/linked-statistics/eurostat

Additionally, this pilot manages other general information related to users and companies such as username/pass, personal and contact information.

The information exchanged between systems will be modelled taking into account the Agricultural Information Model (AIM) defined in DEMETER. Below we provide an example of the use of the AIM concepts in the pilot context.

```
Farm data example:
{
    "@context": [
         "https://w3id.org/demeter/agri-context.jsonld",
    ],
    "@id":"http://w3id.org/demeter/plot/1",
    "@type": "Plot",
    "hasGeometry": "Polygon((-83.6 34.1, -83.6 34.5, -83.2 34.5, -83.2
34.1, -83.6 34.1))",
    "identifier": "1234",
    "area": "35",
    "cropSpecies": {"@id": "http://w3id.org/demeter/CropType/4",
                    "@type": "CropType",
                    "name": "Rapeseed" ,
                    "family": "Brassicaceae",
                    "description": "Rapeseed flowers are yellow and about
17 mm (0.67 in) across. They grow to 100 cm in height ….",
                    "species": "Brassica napus",
                    "agroVocConcept":
http://aims.fao.org/aos/agrovoc/c_1066
                    "production": {
                                productionAmount: “5 tonnes”
                     }
            }
}
Meteo data example:
{
    "@context": [
         "https://w3id.org/demeter/agri-context.jsonld",
    ],
    "@id":"http://w3id.org/demeter/measurement/1",
    "@type": "Measurement",
    "hasValue": "10",
    "isMeasureIn":<http://www.ontology-of-units-of-measure.org/resource/om-
2/degreeCelsius>,
    "relatesToProperty": <https://w3id.org/def/saref4agri#AirTemperature>,
    "measurementMadeBy": {"@id": "http://w3id.org/demeter/station/pl/4",
                    "@type": "WeatherStation",
                    "name": "Poznan Zachod" ,
                    "hasGeometry": "POINT((-83.6 34.1)"
            }
}

FADN data example:
{
    "@context": [
```

```
          "https://w3id.org/demeter/cross-domain.jsonld",
     ],
     "@id":"http://w3id.org/foodie/fadn/year-country#2017-PL",
     "@type": "Observation",
     "name": "2017 (POL) Poland",
     "dataSet": <http://w3id.org/foodie/fadn#dataset_year_country>,
     "SE005": {"@id": "http://w3id.org/foodie/fadn#SE005",
                     "@type": "MeasureProperty",
                     "name": "Economic Size",
                     "hasValue": "28.3"
             }
      "SE010": {"@id": "http://w3id.org/foodie/fadn#SE005",
                     "@type": "MeasureProperty",
                     "name": "Economic Size",
                     "hasValue": "1.6"
             }
        "SE011": {"@id": "http://w3id.org/foodie/fadn#SE005",
                     "@type": "MeasureProperty",
                     "name": "Economic Size",
                     "hasValue": "3568.07"
             }
     ….
     "refCountry": <http://nuts.geovocab.org/id/PL>
}
```

14.1.3 System Extensions and Applications

In this section we are describing how this pilot is integrated into the DEMETER environment. This is the global view of pilot 2.4 in DEMETER Reference Architecture:

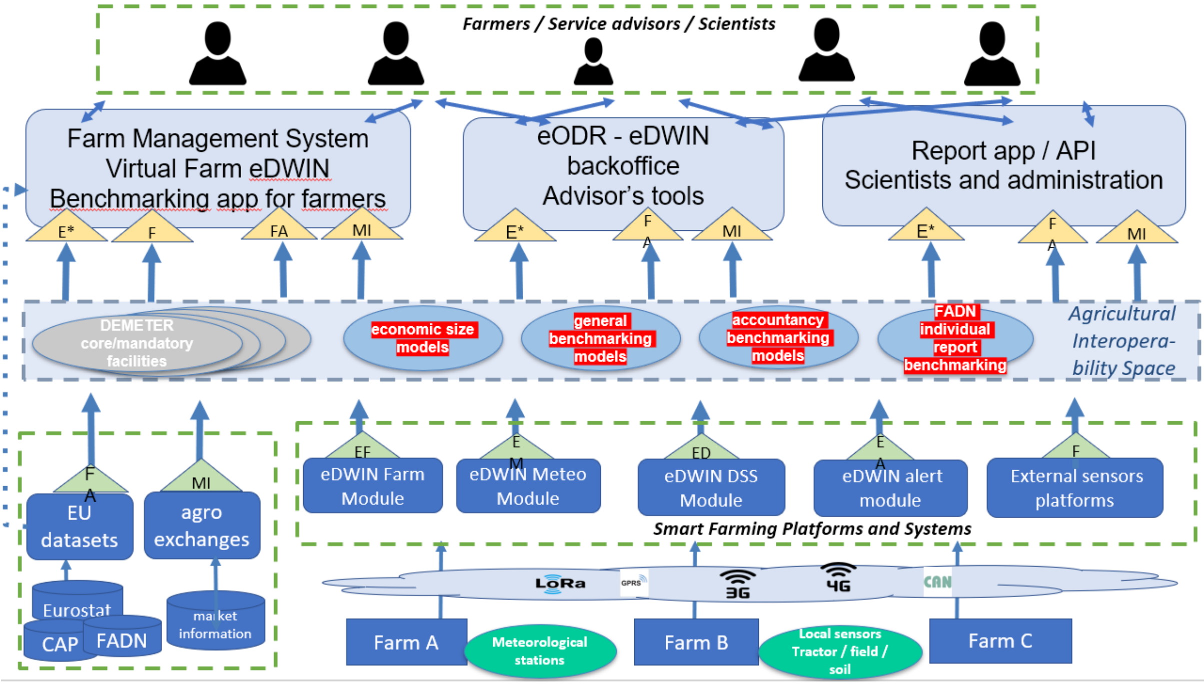

Figure 25: DEMETER Reference Architecture for pilot 2.4

This figure presents the mapping of the DEMETER architecture to the pilot, the delivery of apps through it and the composition of such apps from DEMETER enabled entities, data and services. The raw resources (e.g. various types of sensors) are presented at the bottom. They are connected through the appropriate communication protocols (LoRa, WiFi, etc.) to existing agrotech systems. In this pilot we can find farm management systems (e.g. eDWIN) and external sensors platforms. To make them compatible with DEMETER and to use their data and facilities they will be paired with an appropriate entity (DEMETER Enabler) that will provide an AIM compliant wrapper. The central part of the figure above shows the DEH through which all these entities are offered.

Identified pilot-specific or optional DEMETER enablers that are needed for the realization of the pilot scenario, included in the diagrams as the blue oval shapes, are the following:

- Economic size models: models calculating the economic size of the farm based on data entered by the user or taken from the farm management system (output parameter for benchmarking models)
- General benchmarking models: models allowing direct comparison of data obtained from farms with an economic size close to that defined by the user
- Accountancy benchmarking models: models focusing on comparisons related to accounting – training the algorithms on data concerning production costs etc.
- FADN individual report benchmarking: models based on comparison with other farms of similar economic size but using detailed individual FADN reports (models available only for FADN participants)

The blue components combine all the functionalities that allow data exchange in the system. The data comes from the farm management system, where the farmer enters data manually or uses data served by the FADN. These data allow to calculate the economic size of the farm and then serve as one of the inputs to the benchmarking service. Data is also exchanged with another system dedicated to advisers, where advisers enter information on price quotations. These data are also the input data for the benchmarking algorithms. Meteorological and other farm production data are also important for the algorithms, all from the farm management system.

Below we can see a diagram presenting a general deployment of the pilot in a DEMETER framework. Pilot comprises of three main group of services:

- eDWIN Farm Information and Management system - groups services responsible for information about farms, fields, crops as well as provides modules for serving meteorological data,
- eODR – backoffice for advisors – groups of services where advisors enter general data for the regions, which will then be used in the benchmarking algorithms
- Benchmarking service - integrating data from all sources and calculating the economic size of the farm and ultimately allowing the user to compare with farms of similar economic size

The diagram below presents a high-level deployment of Pilot 2.4 within DEMETER space.

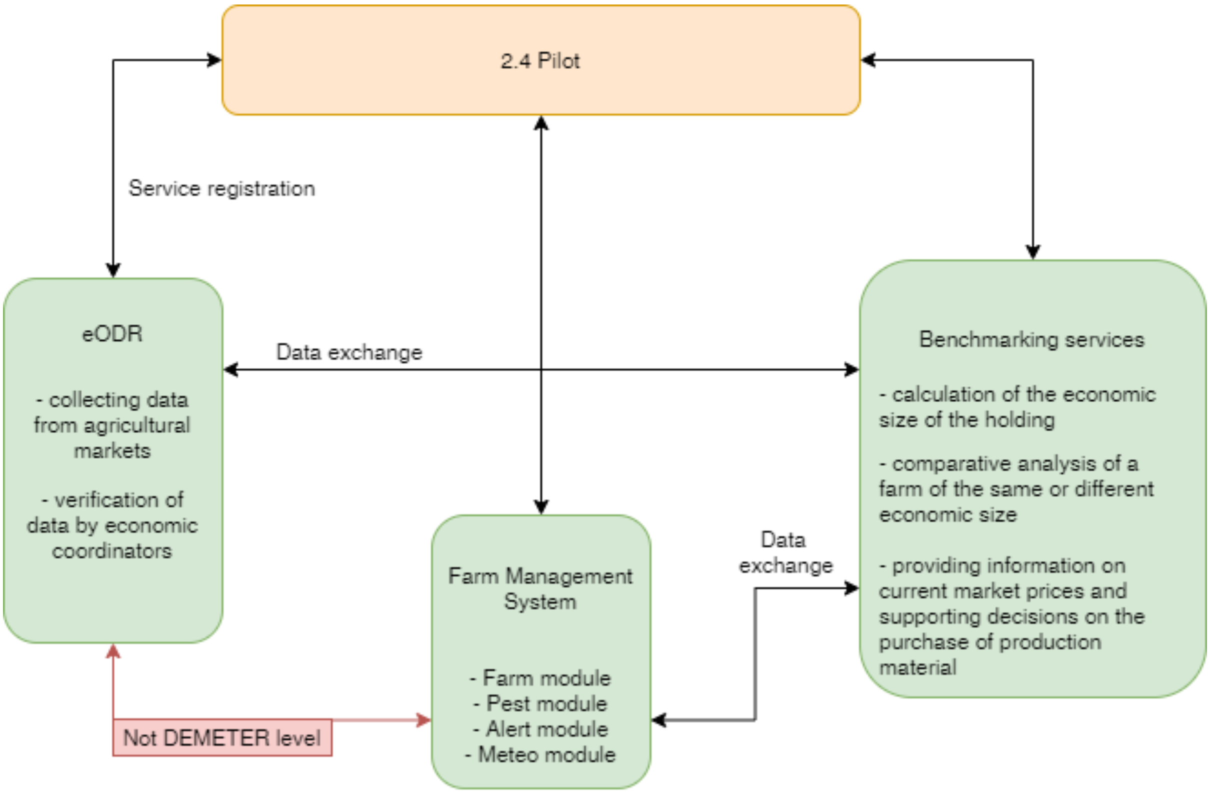

Figure 26: High level deployment of Pilot 2.4 within DEMETER space

15 Pilot 3.1 - Decision Support System to Support Olive Growers

This pilot aims to develop and test a DSS (Agricolus OLIWES) for olive growers, advisers and agri-food processors to address common issues associated with olive tree growing and olive oil production, including integrated pest management of olive fruit fly, irrigation and fertilization management and optimization. The DSS will integrate in-field sensors data, remotely sensed data, a modelling platform and a farm management system, combining weather and soil information with crop traits, to improve the sustainable production of olive groves. Agricolus OLIWES will be deployed, configured and tested in selected olive farms of Italy and Greece, to address different environmental and farming conditions.

15.1.1 Use Case Workflow

For pilot 3.1, we have considered as main input the data provided by farmers (farm, crop and soil data) using the OLIWES Farm Management Information System (FMIS). Agricolus OLIWES is a complete suite that provides decision support to olive growers in the agronomic management and gives alert for pest and disease. Along with the farm data we have integrated weather data provided by weather stations and Copernicus ERA5-Land dataset, and remotely sensed data (Sentinel 2) used to calculate a set of vegetation and water stress indices.

Agricolus OLIWES is composed by the following components:

- OLIWES FMIS (Farm data)
- OLIWES Water Decision Support System
- OLIWES Nutrient Decision Support System
- OLIWES Olive Fruit Fly Decision Support System

Figure 27 presents a general picture of how the information and data required are collected through the different and integrated with the OLIWES FMIS. Agricolus OLIWES will be integrated with the DEMETER Reference Platform comprised by the DEMETER Service Environment, DEMETER Enabler Hub, DEMETER SOCS and Dashboard. In this way it will be possible to connect with the DSS and benchmarking components developed in WP4 and to perform the cross-pilot activities with other Cluster 3 pilots.

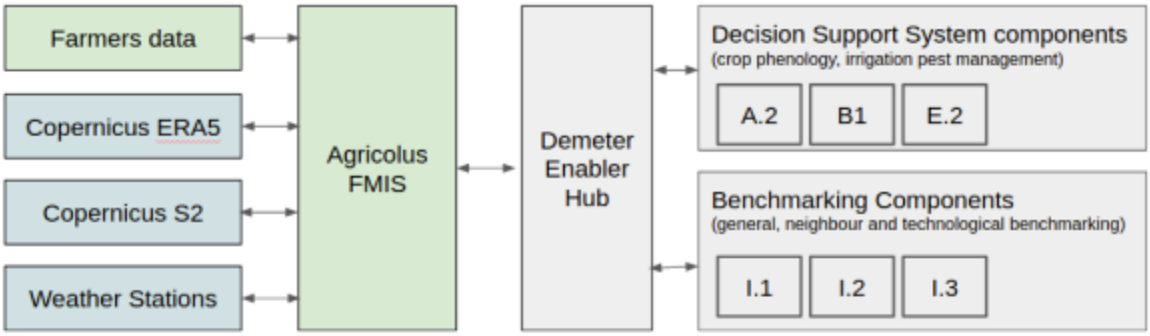

Figure 27: Example of pilot 3.1 flow of information

One of the main general components implemented will allow the user authentication and authorisation to ensure the data security and safety.

15.1.2 Used Data

Pilot 3.1 aims at the implementation and test of Agricolus OLIWES DSS to support olive growers in the optimization of integrated pest management of olive fruit fly, irrigation and fertilization management. The DSS will collect and use different type of data as listed:

- Geospatial data: Location, Field polygon
- Crop data: Variety, Planting density, Year of planting
- Remote Sensing Multi-Temporal Imagery data: Copernicus Sentinel-2 spectral information and derived biophysical parameters (we will calculate 6 different indices)
- Meteorological data: Air temperature, Precipitation, Relative humidity, Wind and radiation if available (not mandatory)
- Soil data: Soil type, Texture, Chemical data (pH, organic matter, CEC), Macro-nutrient content
- Farm data: Historical farm statistics, Irrigation logs, Fertilization log, Crop protection treatment logs, Data on crop phenological observations.
- Registered user data: user credentials, user general information, first name, surname, phone number, e-mail address, farm address

The OLIWES data will be re-modelled using the Agricultural Information Model (AIM) as defined in D2.1 through the AgriFood Data Model and the adoption of specific ontologies related to agriculture features, crops, alerts, properties and systems.

15.1.3 System Extensions and Applications

Figure 28 corresponds to the instantiation of the Reference Architecture defined in DEMETER for pilot 3.1.

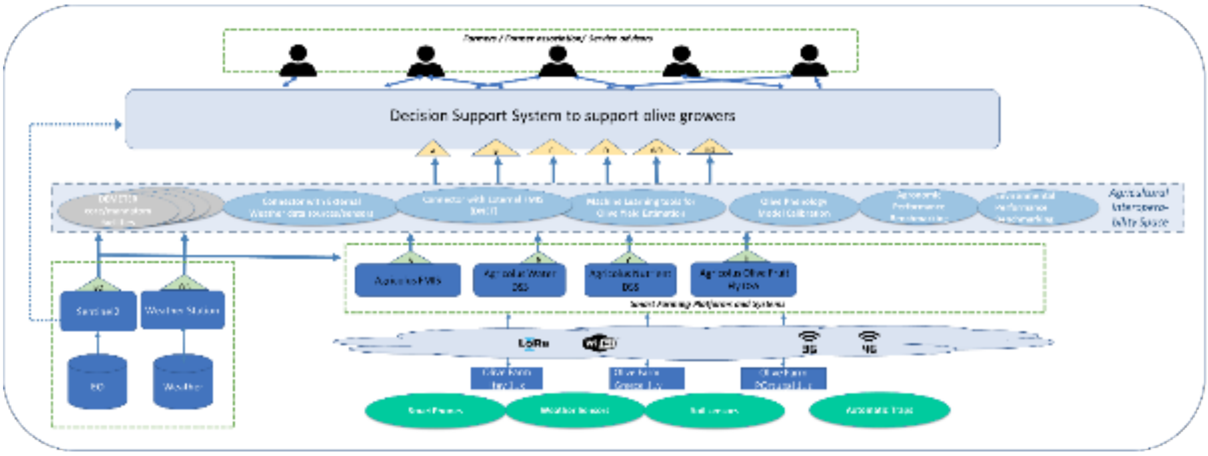

Figure 28: Reference architecture instantiated for Pilot 3.1

This figure presents the mapping of the DEMETER architecture to the pilot, the delivery of apps through it and the composition of such apps from DEMETER enabled entities, data and services. The raw resources are presented at the bottom. They are connected through the appropriate communication protocols (LoRa, WiFi, etc.) to smart farming platforms and system, in which we find as main components:

Agricolus OLIWES - FMIS

The Agricolus FMIS allows the user to identify all the farm assets needed to customize the decision support system in any specific farming condition: a field mapping function allows the user to draw on the map the fields and to associate to them all the relative agronomic data. The user can choose, for each field type of farming, soil analysis and the main fields operations. The Agricolus FMIS can be connected with different devices: traditional agrometeorological stations and IoT sensor networks.

Agricolus OLIWES - Water DSS

The Agricolus Water DSS is based on a water balance model considering weather data (air temperature and precipitation), soil and crop condition. The modelling approach is based on the equation applied to the soil layer explored by roots. The user gets a daily estimation of the water content, and the suggested amount of irrigation needed. The system can adapt itself if the user enters the actual water irrigation. If the user enters the irrigation system parameters, the system can produce the opening time and the suggested shift.

Agricolus OLIWES - Nutrient DSS

The Agricolus Nutrient DSS is based on a balance model connected with a plant model estimating the phenology and the nutrient requirement. The most complex model involves nitrogen estimation. Soil texture, properties and variability will be taken into account to allow the production of soil maps to be used to estimate the actual nitrogen content.

Agricolus OLIWES - Olive fruit fly DSS

A set of models and decision tools are provided to estimate the potential infestation risk for the olive fruit fly at the beginning of the season These models will estimate also the mortality and the phenological development of each generations. The purpose is to obtain an efficient pest management strategy, that can be achieved by combining climate variables with agricultural information in the field. This is mandatory in area-wide pest management approach to coordinate the timing of treatments at farm level.

To make these components compatible with DEMETER and to use their data and facilities, they are paired with an appropriate entity (DEMETER Enabler) that will provide an AIM compliant wrapper. The central part of Figure 28 conforms the DEH through which all these entities are offered. On the left side, we find DEMETER mandatory entities (grey) to be used by the optional ones (blue) needed by this pilot where we can find:

- Connector with external weather data sources/sensors: to provide the connection with external data source and IoT sensors;
- Connector with external FMIS (DNET): Water DSS, Nutrient DSS and Olive fruit fly DSS can be connected with external FMIS
- Machine Learning Tools for olive yield estimation: using data fusion and machine learning algorithms with different inputs (i.e. imagery, historical data etc.). This component will provide an estimation of the yield;
- Olive phenology model calibration: with machine learning approach, historical observations, Copernicus ERA5-Land dataset. This component will test and calibrate the existing olive tree phenology model of OLIWES.
- Agronomic performance benchmarking: with benchmarking tools developed within DEMETER and farm data. This component will compare the farm agronomic sustainability with other similar farms.
- Environmental performance benchmarking: with benchmarking tools developed within DEMETER and farm data. This component will compare the farm environmental sustainability with other similar farms.

These enablers offered by the DEH are used to compose the DEMETER Enabled Applications for the business solutions of the pilot that are presented at the top of Figure 28:

- Decision Support System to support olive growers

16 Pilot 3.2 - Precision Farming for Mediterranean Woody Crops

This pilot aims at promoting technology, methods and IoT solutions to optimise precision farming practices of Mediterranean Woody Crops (Apple, Olive and Grape), considering the small farmers' economic constraints. The proposed solutions (IoT and Ground Robots) will enable a more efficient usage of inputs such as water, energy, macro-nutrients, and pesticides, thus increasing the profits of small farmers and reducing their environmental impact. The main objective is to support real-time monitoring and control of plants, water supply and nutrients, using IoT Sensors and Agricultural Robots on the field for phenotyping, as well as enabling precision-spraying and through the usage of satellite/aerial imagery for yield potential estimation.

16.1.1 Use Case Workflow

The following image presents a diagram providing the flow of information for pilot 3.2.

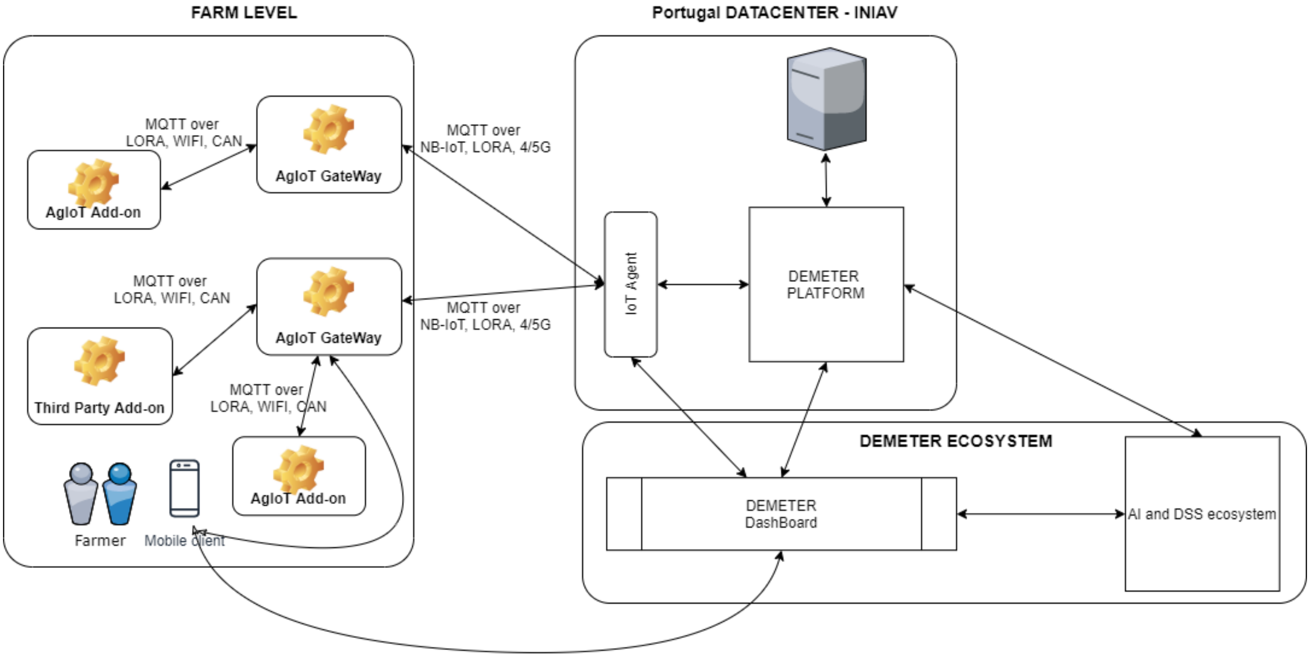

Figure 29: Pilot 3.2 Component diagram

The pilot has the following components and extensions:

- IoT Devices: Based on AgIoT platform for collecting various data from the field (temperature, humidity, rain perception, machinery data, leaf wetness, soil moisture, insect count), on static spots or on Agricultural machinery and/or robots.
- Portuguese Datacenter - national datacentre build considering DEMETER Middleware definition, where medium/small farmers can store their data and access easily to a marketplace with decision support systems apps benchmarked, validated and compatible to this datacentre.
- Farmers and end user application: to provide data about irrigation instructions, disease prediction as well as data about product's authenticity and proof of origin together with the usual information about the products

16.1.2 Used Data

This pilot, through the use of AgIoT gateway, will map different data as listed below:

- Geospatial data: Location, Farm boundaries
- 2D maps imagery: NDVI maps, NPK maps, Yield maps
- Meteorological data: Air temperature, air humidity, air quality, solar radiation, rainfall
- Soil data: Soil temperature, soil humidity, soil conductivity, NPK
- Plant Grow: Sap Flow, Trunk Diameter, Leaf Humidity
- Water data: Salinity, Water NPK, Cater consumption
- Farm data: Historical yield statistics, Farm crop data

It will also use data from registered users:

- User credentials: Username, Password
- User general information: First name, Surname, Phone number, Email address

A more detailed description of the data produced by AgIoT devices in JSON format over MQTT the tables presented in Annex 3 – Technical specification provided by specific pilot.

The DEMETER Enablers will ensure the secure exchange of data, the interchange mechanisms, and the semantic interoperability by guaranteeing the DEMETER AIM format. Personal information, user credentials and geospatial information (location, farm boundaries, crop-specific information) will be directly modelled according to AIM, as defined in D2.1. Information from IoT sensors and weather station will be remodelled via AIM-compliant wrappers. The Pilot 3.2 data (from AgIoT) will be re-modelled using the AIM as defined in D2.1 through the AgriFood Data Model and the adoption of specific ontologies related to agriculture features, crops, alerts, properties and systems.

```
Farm data:
{
    "@context": [
         " https://w3id.org/demeter/agri-context.jsonld",
    ],
    "@id":"http: https://w3id.org/demeter/demeter/plot/",
    "@type": "Plot",
    "hasGeometry": "Polygon",
    "identifier": "Number",
    "area": "Number",
    "cropSpecies": {"@id": " https://w3id.org/demeter/CropType/",
                    "@type": "CropType",
                    "name": "String" ,
                    "family": " String",
                    "description": "String",
                    "species": "String"
            }
}

Meteo data:
{
    "@context": [
         "https: https://w3id.org/demeter/agri-context.jsonld",
    ],
    "@id":" https://w3id.org/demeter/measurement/",
    "@type": "Measurement",
    "hasValue": "Number",
    "isMeasureIn":<http://www.ontology-of-units-of-measure.org/resource/om-
2/degreeCelsius>,
    "measurementMadeBy": {"@id": " https://w3id.org/demeter/station/",
                    "@type": "WeatherStation",
                    "name": "String" ,
                    "hasGeometry": "POINT"
            }
}
```

16.1.3 System Extensions and Applications

Figure 30 presents the mapping of the DEMETER architecture to the pilot, the delivery of apps through it and the composition of such apps from DEMETER enabled entities, data and services.

The raw resources are aggregated by the AgIoT Ecosystem, as presented at the bottom. The AgIoT will be connected a national datacentre, that is being built by Ubiwhere, were medium/small farmers can in the future store their data and access easily to a marketplace with decision support systems apps benchmarked, validated and compatible to this datacentre

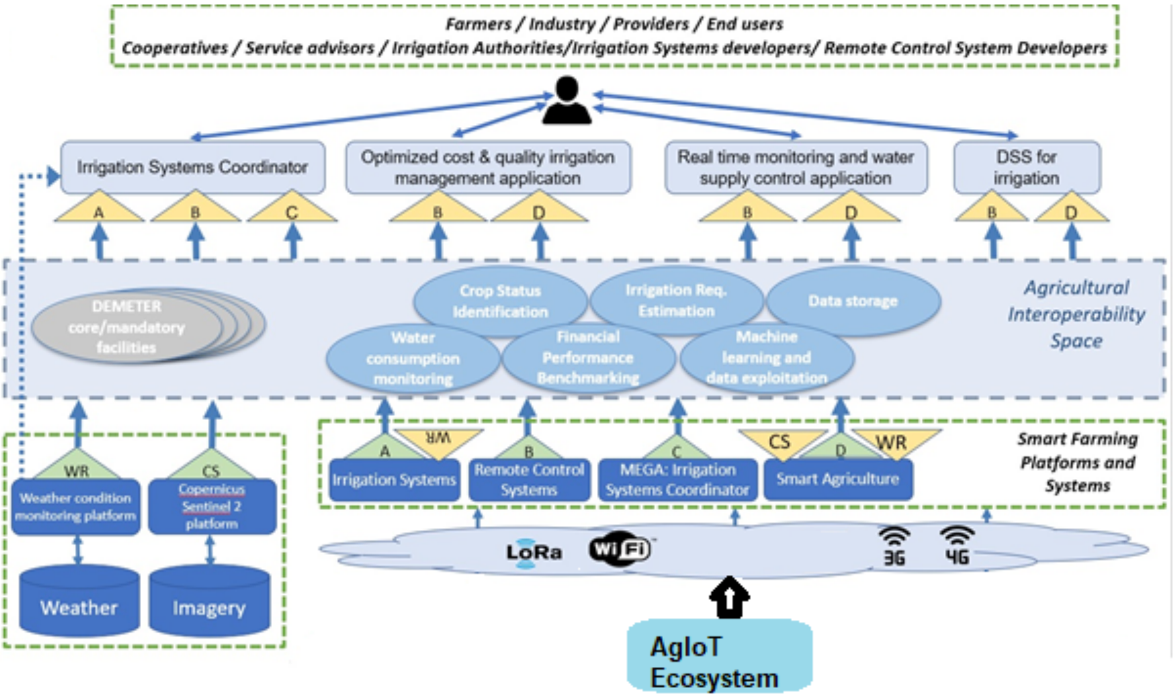

Figure 30: Instance of DEMETER Reference Architecture for Pilot 3.2

The Demeter Enabled Applications for the business solutions of the pilot that are presented at the top of the figure:

- Irrigation optimization
- Pest detection and treatment application
- Fertilization optimization
- Automated documentation of arable crop farming processes

17 Pilot 3.3 - Pest Management Control on Fruit Fly

Pilot 3.3 aims at providing a set of tools to monitor and manage the Mediterranean fruit fly (Ceratitis capitata) which is a dangerous pest with a wide range of distribution and host plants. Automatic capture traps and remote sensing technologies will be used to predict the thread and support decision making. The pilot implementation will be deployed and tested in the Valencian Community region with more than 170.000 hectares involved.

17.1.1 Use Case Workflow

For this pilot, we have considered as inputs: crop status, number and location where sterile flies have been released and location and percentage of sterile flies detected in the trap. Figure 31 presents a general picture of how this pilot is going to work.

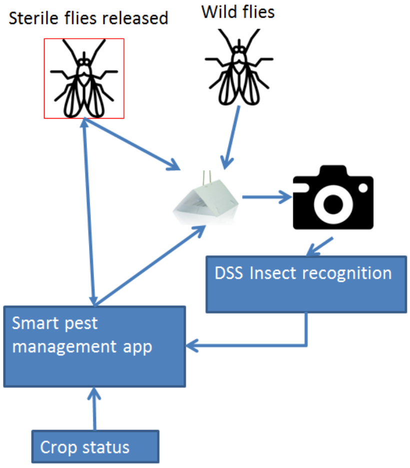

Figure 31: Example of pilot 3.3 flow of information

The smart pest management app decides where the different traps are going to be placed, and, after that decides how many and where sterile flies have to be released. The different traps capture different flies and take a photo which will be sent to DSS insect recognition. Once the percent of sterile flies has been calculated, it is sent to the smart pest management app which, taking into account the last release of sterile fruit flies, will decide where the news sterile flies are going to be released.

17.1.2 Used Data

This pilot aims at monitoring and managing the Mediterranean fruit fly. For this reason, the data it manages cover the following aspects:

- Geospatial data: Location, Geographical Information System (SigPac), EGNSS (GPS/EGNOS/Galileo)
- Climate data: Air temperature, air humidity, wind speed, wind direction, solar radiation and rain
- Released data: Information about the number of flies that has been released, when, how (can be done by drone, by plane or by foot for example) and where
- Photos data: The image that will be processed and when and where it has been taken

Additionally, this pilot manages other general information related to users and companies such as username/pass, personal information, or related to companies. This information is modelled thanks to the AIM already defined in Deliverable 2.1 through the AgriFood Data Model. The Agricultural Information Model (AIM) will be used also to format the data related to time or geographic among others and some specific ontology related to alerts and pest.

17.1.3 System Extensions and Applications

Figure 32 presents the mapping of the DEMETER architecture to the pilot, the delivery of apps through it and the composition of such apps from DEMETER enabled entities, data and services. The raw resources (e.g. various types of devices) are presented at the bottom. They are connected through the appropriate communication protocols (LoRa, WiFi, etc.) to existing Farming Management Information Systems (FMIS) or IoT Device Platforms. In this pilot we can find:

- AI Powered Computer Vision Solution: Systems that are going to receive the photos that the Automatic traps have taken, and it would make the edit to make it easier to be processed.
- IoT Data Capture & Monitoring Platform: It is going to manage all the information related to environmental that are going to be recorded.

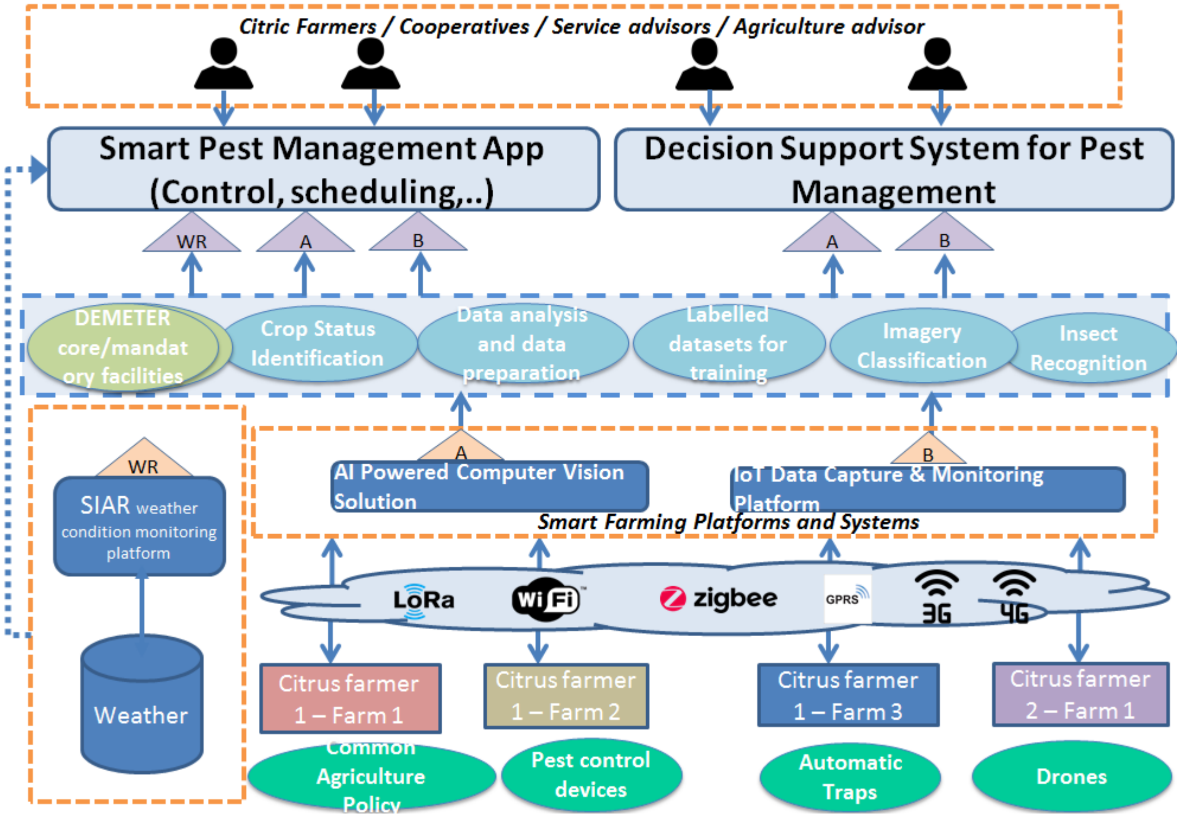

Figure 32: Reference architecture instantiated for Pilot 3.3

To make them compatible with DEMETER and to use their data and facilities they are paired with an appropriate entity (DEMETER Enabler) that will provide an Agricultural Information Model (AIM) compliant wrapper. The central part of the figure above conforms the DEH through which all these entities are offered. On the left we find DEMETER mandatory entities (grey) to be used by the optional ones (blue) needed by this pilot where we can find:

- Crop Status identification: It is going to be used in order to plan how the traps are going to be more effective and where the sterilized flies have to be released.
- Data analysis and data preparation: Tool that is going to analyse the different data before send to the Smart pest management App.
- Labelled datasets for training: Tool that is going to be used to label the different photos that are going to be taken in order to give a better training.
- Imagery Classification: Tool that is going to be used to make a first classification in order to get a better result in the insect recognition module.
- Insect Recognition: Tool that is going to be used to recognise the fruit flies that are in the image.

These enablers offered by the DEH are used to compose the DEMETER Enabled Applications for the business solutions of the pilot that are presented at the top of the figure:

- Decision support system for pest management.
- Smart pest management App (Control, scheduling, …)

17.1.4 Issues identified in the Implementation Plan

Pilot 3.3 addresses fruit fly, which is a summer pest. Because DEMETER launched on September 2019, the provisional start of Pilot Round 1 according to the proposal (M12, i.e., August 2020) is at the end of the summer.

Besides, this pilot has two different phases that cannot be run in the same time. A specific trap is going to be developed and after that a computer vision-based counting module is going to be used to identify the amount of fruit flies.

The development can start at the same time, but the computer vision-counting module needs a set of photos to be trained so it requires the photos for its validation and finalisation. Until the trap can take the photos, the vision-counting module cannot be trained. These photos have to be taken in the real situation which means it would be better if the photos that are going to be used will be taken in summer, when the fruit fly is a biggest problem.

So, it would be better if this pilot provides info to Deliverable 5.5 and 5.6 with about a three- or four-months delay in order to give information that can be useful.

18 Pilot 3.4 - Open Platform for Improved Crop Monitoring in Potato Farms

This Pilot aims at integrating field machinery data with remote sensing, meteorological and soil data into the WatchITgrow (WIG[6]) platform. The field data (planting date, planting distance, detailed yield information) is an important source of information for the calibration and validation of the analytical crop models in WIG that use satellite data, meteorological data and soil information as inputs to model crop growth and predict yields. The in-field data could allow the development of a purely data-driven model instead of fine-tuning physical models. The enhanced crop growth models will be used to give

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[6] WatchITgrow (WIG): http://watchitgrow.be

advice to farmers for the optimization of field management practices (optimal harvest date, variable rate haulm killing, variable rate fertilization, irrigation advice).

18.1.1 Use Case Workflow

The following figure presents the main components of this pilot.

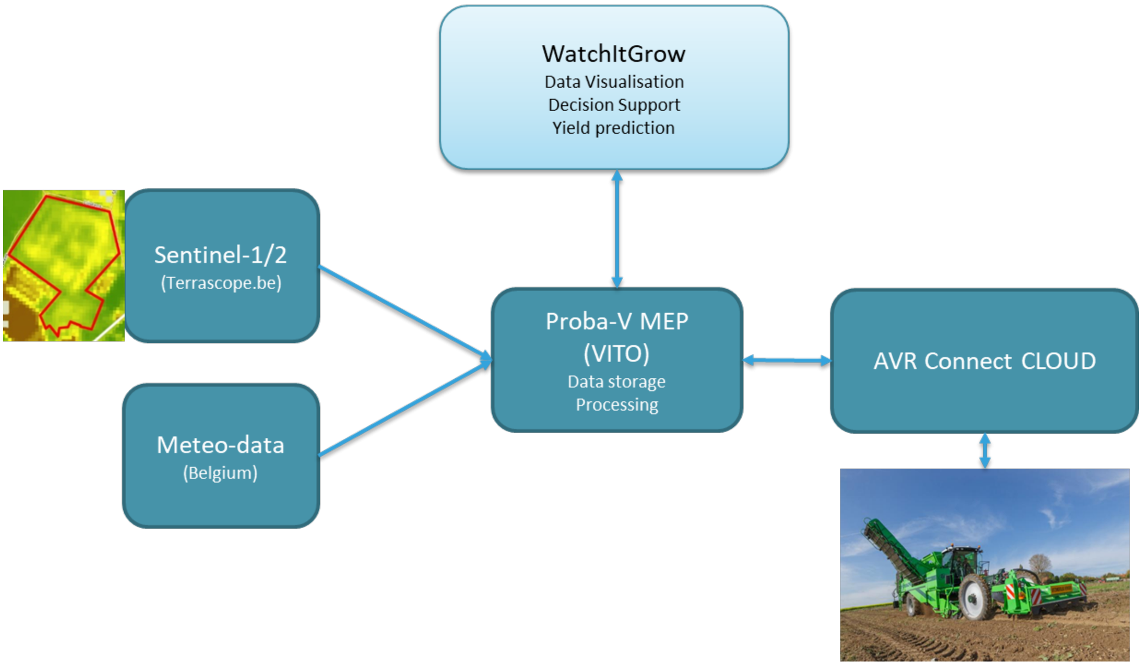

Figure 33: Pilot 3.4 components diagram

These entities will be adapted to comply with the DEMETER Reference Platform requirements (ontologies, metadata, API’s, security, …). This way, data and services can be exchanged also with other platforms and end-users.

The main components of the pilot are discussed below.

WatchItGrow (VITO): WatchITgrow uses remote sensing data (Sentinel 2, Copernicus program), combined with local meteorological and soil data, to inform farmers via a user-friendly web application on the status of their crops and on expected yield.

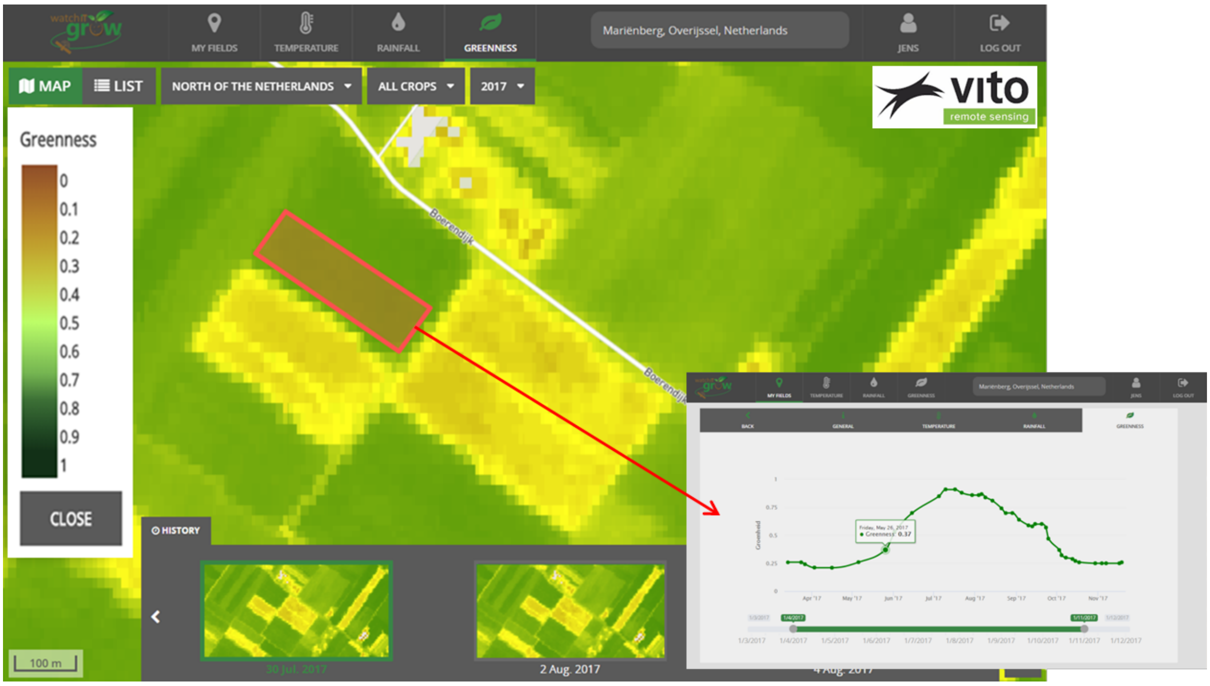

Figure 34: WatchItGrow web application for visualization of Satellite data and crop growth data

VITO hosts the **PROBA-V Mission Exploitation Platform (MEP)**[7], a cloud platform providing scalable computing power and direct data accessibility to PROBA–V and Sentinel products and derived parameters, as well as selected high-resolution data. The platform applications are developed and deployed on a Hadoop cluster at the *VITO data center* and a private cloud environment at VITO (OpenStack) is used to provide virtual machines (VMs) to third-party users. Next to CPU power, the cluster also offers a limited number of GPU nodes for internal users for the purpose of training deep learning models. *Tensorflow* and *sklearn* libraries are available on the VM for implementation of machine learning algorithms.

AVR Connect is the recently started IOT cloud platform that collects data from the field machinery (potato planters, yield sensors on the potato harvesters) using 4G communication and makes the data available to third parties. Geotagged yield data will be collected at a frequency 1Hz, which leads to very detailed yield maps.

- AVR Field machinery data, automatically uploaded to AVR Connect Cloud using 4G:
    - Geotagged and timestamped planting data (planting distances)
    - Geotagged yield data collected at a frequency of 1Hz using yield sensors on the field machinery

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[7] PROBA-V Mission Exploitation Platform: http://proba-v-mep.esa.int

18.1.2 Used Data

Pilot 3.4 aims to extend the WIG platform to provide advice on irrigation and variable rate fertilization management. The DSS will collect and use different type of data as listed:

- Geospatial data: Location, Field polygon
- Crop data: Variety, Planting density, Planting date,
- Remote Sensing Multi-Temporal Imagery data: Copernicus Sentinel-2 spectral information and derived biophysical parameters (NDVI, FAPAR, LAI), Sentinel-1 SAR data
- Meteorological data: Air temperature, Precipitation, Relative humidity, Wind and radiation if available (not mandatory)
- Soil data: Soil type, Texture
- Farm data: Historical farm statistics, Irrigation logs, Fertilization logs, Crop protection treatment logs, Phenology observations, Data on historical yields
- Machinery data: Planting date, Location EGNSS (GPS/EGNOS/Galileo), Planting distance, Geo-located detailed crop yield, measured at 1Hz, on the AVR Puma 4.0 harvesting machines
- User data: User credentials (email address, password), User general information (first name, surname, phone number, farm address)

The WIG data will be re-modelled using the Agricultural Information Model (AIM) as defined in D2.1 through the AgriFood Data Model and the adoption of specific ontologies related to agriculture features, crops, alerts, properties and systems.

18.1.3 System Extensions and Applications

The following image corresponds to the instantiation of the Reference Architecture defined in DEMETER for pilot 3.4.

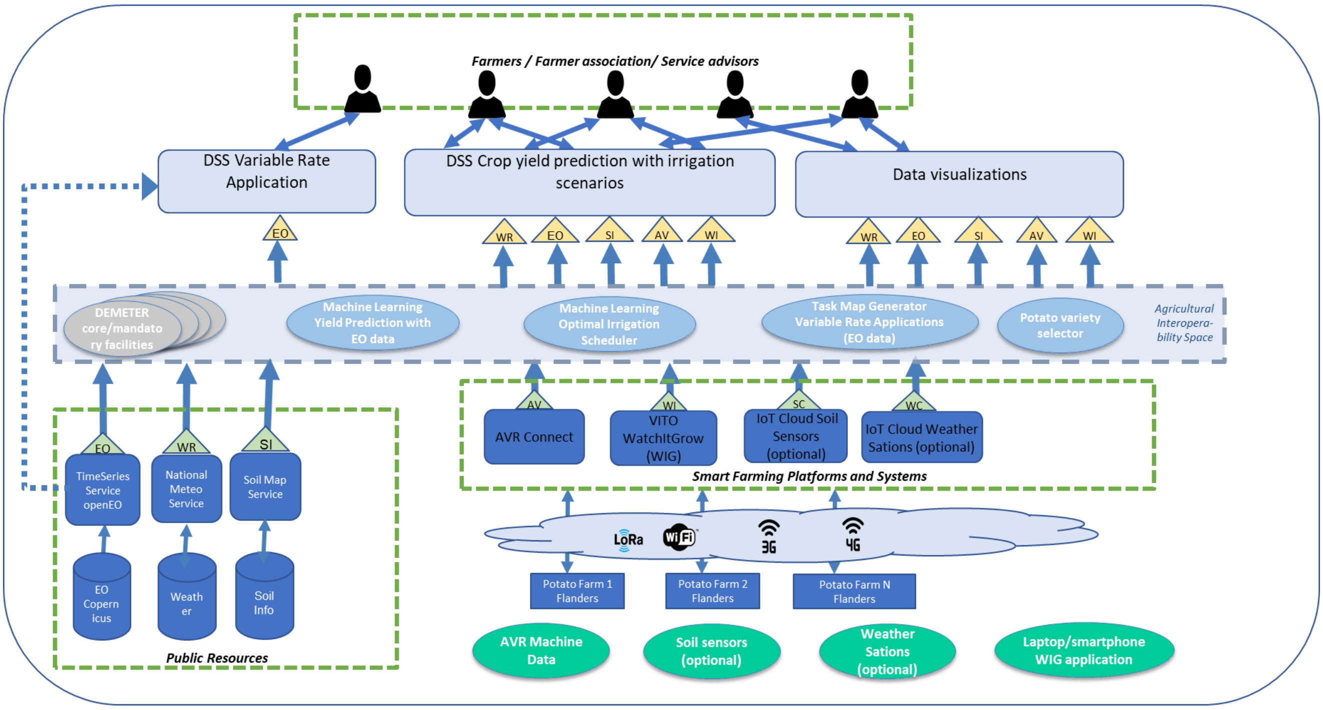


Figure 35: DEMETER architecture for pilot 3.4

The raw resources (e.g. various types of devices) are presented at the bottom. They are connected through the appropriate communication protocols to existing cloud applications that process and serve the data. In this pilot we can find:

- AVR Connect: it collects planting data (date, planting distance, crop type) and harvest data (yield maps at 1 Hz) and makes them available through the cloud application to third parties
- VITO WatchItGrow: web application for farmers to upload data on field activities and look at relevant data for their fields (satellite imagery, weather data, yield predictions).
- IoT cloud solutions for soil sensors and weather stations: optional for this pilot; instead of using weather data from National instances, a DEMETER-compatible cloud solution for IoT sensors may be integrated to provide more detailed info on soil and weather conditions.

To make them compatible with DEMETER and to use their data and facilities they are paired with an appropriate entity (DEMETER Enabler) that will provide an Agricultura Information Model (AIM) compliant wrapper. The central part of the figure above describes the DEH through which all these entities are offered. On the left we find DEMETER mandatory entities (grey) to be used by the optional ones (blue) needed by this pilot where we can find:

- Machine Learning yield prediction: ML Component that will offer services for yield prediction on field-level based on satellite data, weather data and soil data.
- Machine Learning optimal irrigation scheduler: ML Component that will offer advice on irrigation on field-level based on crop status and estimation of soil moisture.
- Variable rate application: provide maps for variable rate application of fertilizer.

- Potato variety selector: based on historical yields, provide information on what potato varieties are likely to perform best for soil type and weather conditions.

These enablers offered by the DEH are used to compose the DEMETER Enabled Applications for the business solutions of the pilot that are presented at the top of the figure:

- Variable Rate Application.
- Crop yield prediction (for irrigation scenarios).
- Data visualisation.

19 Pilot 4.1 - Dairy Farmers Dashboard for the Entire Milk and Meat Production Value Chain

Pilot 4.1 focuses on a farmer's digital dashboard for a better view/outlook over the farm activities and the farmer's cooperation with both private and public actors, more efficient use of digital tools the farmer applied, and better and more customized decision support for each farmer. The focus is primarily on dairy farms in the pilot, but the concept will include all types of farms. In the pilot, the company Agricultural Dataflow leads the work with developing the broad dashboard while the company Mimiro has a specific activity on developing a model for milk prognosis.

Agricultural Dataflow will build data infrastructure and models of farmers dashboard in a co-creational process based on the Agricultural Dataflow infrastructure today, specially related to the companies' authentication and authorization systems, with farmers and related partners and industries in Norway. Mimiro is one of these partners.

The aim of Mimiros activity in pilot 4.1, is to develop a model for milk prognosis. These forecasting models for milk production are essential to plan and optimize the production in terms of economy, animal numbers, milk quality and feed production. For this reason, forecasting models must be developed at different aggregated levels ranging from single animals, herd groups, herd level, up to regional and national levels. The pilot uses data from dairy farms with automatic milking systems (milking robot). Currently, we can count with a total number of 570 dairy farms which will provide basic cow (age, lactation no., days in milk, breed) and milk production (milking frequency, milk yield) data.

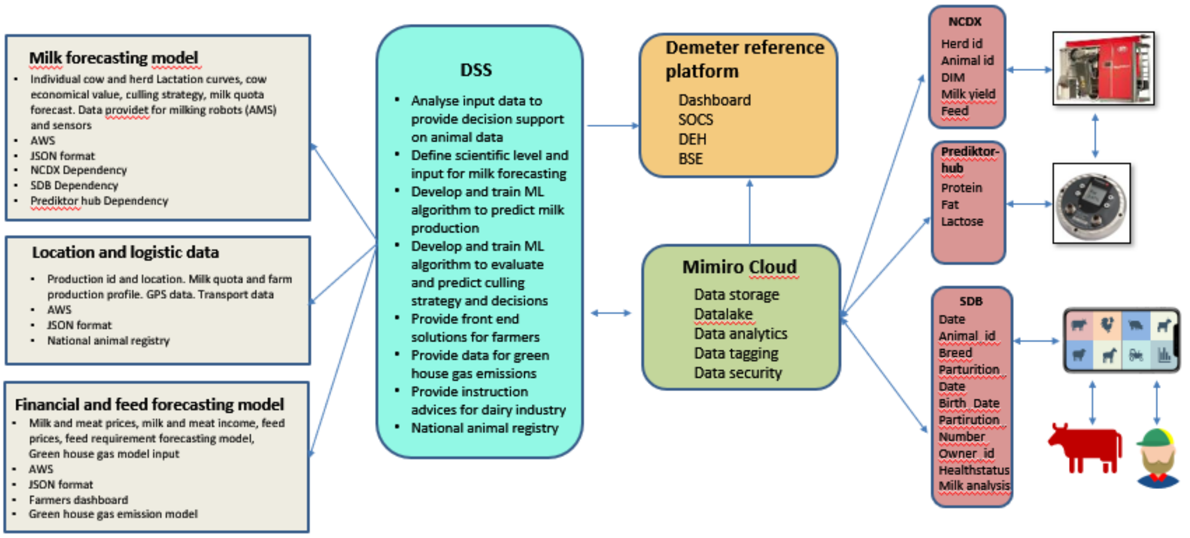
The pilot will use machine learning techniques to develop algorithms for milk yield forecasting and culling strategy. This way farmers will be provided with an integrated 360-solution application to optimize the farm production.

19.1.1 Use Case Workflow

Pilot 4.1 proposes will offer a dashboard for accounting, benchmarking and milk production prediction. This dashboard will be generated using a wide variety of enablers: climate (Climate Accounting), economic (Financial Performance Benchmarking, Economic Performance, Supplier Order Payment) and cow/milk related (Cow Growth Function Model, Lactation Curve Algorithms, Milk Volume Model, Milkman Forecast).

The broad dashboard activity has data input from involved farmers and other related companies, and plan to launch new apps and solutions for Norwegian farmers, with easier registration and insight to continuously improve production. At the same time, pilot 4.1 will build a digital ecosystem for agriculture, for external suppliers, researchers and advisors. Agricultural Dataflow is in the process of designing a "farmers dashboard" that will integrate various stand-alone dashboards, farm management systems, app's and ICT-programs for the farmer in a common framework. The company also develops a system for data collection, modelling and calculation of greenhouse gas emissions on farm level. This tool will also be a part of the overall picture in the farmers dashboard and will be integrated with other farm management systems for optimizing the farm productivity with the Agricultural dataflow infrastructure.

The Milk prognosis in Pilot 4.1 has milk data input from different sources: historical production data including data on milk quality and animal health, data from milk fat and protein sensor and data from the milking robot, e.g. milk yield, milking time, milk flow. The figure below presents a general picture of how the data is collected and used to develop a DSS for milk forecasting. The information is collected from different data sources and integrated into the Mimiro cloud platform. Information will further be integrated into the DEMETER Enabler Hub.



Milk forecasting model

- Individual cow and herd Lactation curves, cow economical value, culling strategy, milk quota forecast. Data providet for milking robots (AMS) and sensors
- AWS
- JSON format
- NCDX Dependency
- SDB Dependency
- Prediktor hub Dependency

Location and logistic data

- Production id and location. Milk quota and farm production profile. GPS data. Transport data
- AWS
- JSON format
- National animal registry

Financial and feed forecasting model

- Milk and meat prices, milk and meat income, feed prices, feed requirement forecasting model, Green house gas model input
- AWS
- JSON format
- Farmers dashboard
- Green house gas emission model

DSS

- Analyse input data to provide decision support on animal data
- Define scientific level and input for milk forecasting
- Develop and train ML algorithm to predict milk production
- Develop and train ML algorithm to evaluate and predict culling strategy and decisions
- Provide front end solutions for farmers
- Provide data for green house gas emissions
- Provide instruction advices for dairy industry
- National animal registry

Demeter reference platform

Dashboard
SOCS
DEH
BSE

Mimiro Cloud

Data storage
Datalake
Data analytics
Data tagging
Data security

NCDX

Herd id
Animal id
DIM
Milk yield
Feed

Prediktor-hub

Protein
Fat
Lactose

SDB

Date
Animal_id
Breed
Parturition_Date
Birth_Date
Partirution_Number
Owner_id
Healthstatus
Milk analysis

Figure 36: Pilot 4.1 Milk prognosis – overview of information flow and DSS output

The diagram describes how the data will be created, collected and processed in the milk prognosis activity.

As a part of the milk prognosis activity and necessary interaction with farmers, we want to test the following value hypotheses related to the milk forecasting model (definition: tests whether the new product or service will create value for the customer):

- The farmer wants a milk prognosis, which presents an estimate of future milk production

- The farmer wants a milk prognosis based on his individual cows and more of the information that is already available about his/her production, in order make more precise predictions
- The farmer wants to see his income from delivered milk so far this year (not just amount/litres of milk delivered)
- The farmer wants to know the financial value of future produced milk (not just the amount)
- The farmer wants to know how much "lost income" there is in the milk production, due to sub-optimal results in relevant areas of his production.
- The farmer wants to see the financial effect (gains) of improving results in relevant areas of his/her production.
- The farmer wants to simulate his maximum production capacity (for decision support when considering expanding his quota).

For the broad dashboard activity, we will have similar interaction and testing activities.

19.1.2 Used Data

To develop a milk prognosis to be used by the farmers data must be collected from different sources, which includes data from different integrated sources, i.e., the NCDX (Nordic Cattle Data exchange), National herd system (including animal registry system) and IOT data from fat and protein sensor.

Input: basic cow data (age, lactation no., days in milk, breed) information and milk production (milking frequency, milk yield). Data is available from 2018 -2020. The data Will be divided in two subsets, across years, one for model training and one for model development and testing. Below there is an example of classification of input data used to predict individual cow milk prognosis

- Animal Id
- BirthDate
- Breed
- Parturition date
- Days in Milk (DIM)
- Milk sample date
- Average daily production
- Daily fat, protein, lactose
- Monthly milk fat, protein, lactose, urea, cell count
- Health status
- Concentrate date
- Concentrate amount
- Concentrate unit
- Forage amount

Output: milk forecasting DSS. Below there is an example of classification of output data used to predict individual cow milk prognosis.

- Animal_Id
- Breed
- Parturition date
- DIM
- Milk sample date
- Average daily production
- Daily fat, protein, lactose
- Predicted milk yield, n+1
- Predicted milk yield, n+4
- Predicted milk yield, n+Nn
- Predicted milk yield
- Animal culling value
- Culling date
- Concentrate amount
- Forage amount

The milk prognosis information will be related to the relevant elements of the AIM as defined in D2.1 through the AgriFood Data Model and the adoption of specific ontologies related to milk prognosis and climate calculation features, alerts, properties and systems.

The DEMETER Enablers will ensure the secure exchange of data, the interchange mechanisms and the semantic interoperability by relating to the AIM model and format. In particular, personal information, user credentials and geospatial information (location, climate and milk production related information) which will be related to AIM elements, as defined in D2.1. Where necessary additional elements might be suggested for further AIM extensions and revisions.

19.1.3 System Extensions and Applications

The Milk prognosis and dashboard activity will be integrated into the DEMETER environment, including which DEMETER components are required. The figure below shows an overview of the Reference Architecture defined in Pilot 4.1.

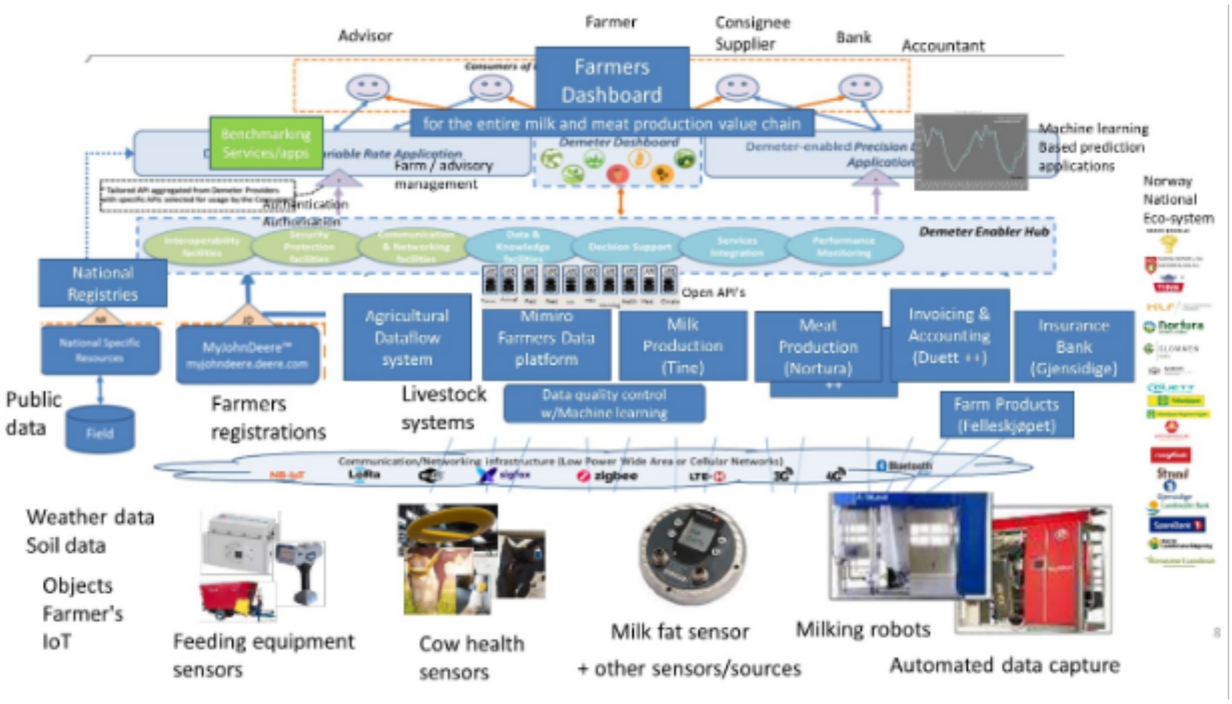


Figure 37: Reference architecture related to the Pilot 4.1

The pilot will be integrated into the DEMETER environment, including which DEMETER components to be used both for visualization and benchmarking. In addition, the solution will be built into the Mimiro Eana Ku application. This is a management tool for the dairy farmers which consists of a DSS solution and a system for planning and simulation.

The data is presented at the bottom of the figure and they are connected through the appropriate communication protocols, e.g. using existing or new farm management systems. An important contribution in Pilot 4.1 Milk forecast is to use machine learning (top part of the figure) to develop forecasting models as an input to the DSS.

20 Pilot 4.2 - Consumer Awareness: Milk Quality and Animal Welfare Tracking

The pilot intends to optimize the flow of information between the actors involved in their short milk supply chain. The scope is to integrate the data collected from the breeding farm in order to use them to give an overview of the most important animal welfare and milk yield indicators. These indicators will be used to give insights on the quality of milk, that is strictly connected to the animal welfare, and will be accessible by the processing company through a single and dedicated point of access.

20.1.1 Use Case Workflow

Pilot 4.2 focuses both on animal welfare and milk quality (two topics closely linked). Two kinds of data sources are used:

- Animal welfare-related data sources (i.e. pedometer, Data Log devices for temperature control and Aficollars[8] for rumination, eating habits and respiration monitoring) applied in the breeding and milking phase;
- Milk quality-related data sources used in the breeding farm for the separation of dairy yield between higher and lower quality (Afilab[9]), in the transportation phase of the raw milk to the processing company (i.e. Milk Box MKII[10] automatic lactating device) to allow temperature monitoring and finally in the processing plant MilkoScan FTIR[11] equipment to analyse the characteristics of all milk collected.

The following picture shows how this information is gathered through the different sensors and devices, used by the DEMETER Enhanced-Entity (DEEs) and integrated into the DEMETER environment.

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[8] https://www.afimilk.com/cow-monitoring/

[9] https://www.afimilk.com/afilab

[10] http://www.milksampler.com/

[11] https://www.fossanalytics.com/en/products/milkoscan-7-rm

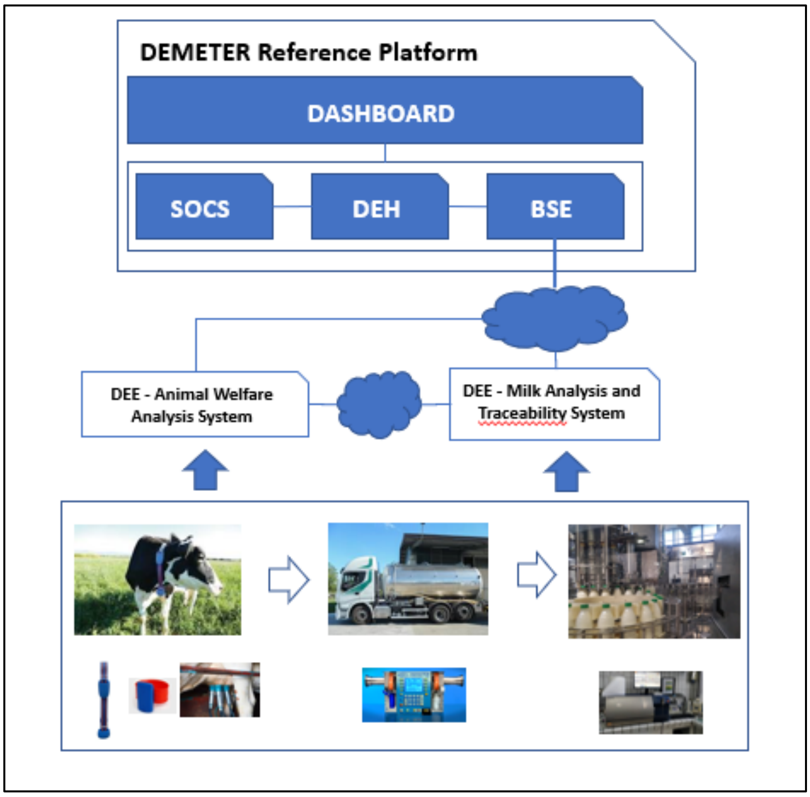

Figure 38: Pilot 4.2 flow of information

The produced information, thanks to the DEMETER Enablers Client-side can be integrated into the DEMETER Reference Platform in order to be exchanged also within other platforms.

The data collected throughout the value chain (from the producer to the processor), will serve on one hand to feed the analysis system for animal welfare (DSS), on the other hand to feed the Milk Analysis and Traceability System based on blockchain technology.

The data related to animal welfare are collected by wearable devices and loaded into the system in CSV format.

The process of data collection and analysis related to traceability can be summarized as follows: the milk collected at Maccarese by milking is analysed by Afilab devices; milking data and files are generated from a milking parlor control system capable of analyzing in real time the quality of the milk produced, while an output routine produces the files in CSV format. The milk is then stored in silos, where the temperature is monitored. After that, the milk is then sent to Latte Sano (in the same week in which it was produced): during the transport on the tank the temperature of the milk is monitored using the Milk Box device; both the tractor and the tank are equipped with GPS satellite. Once Maccarese milk arrives to Latte Sano, a sample is extracted on which a first analysis is made through the MilkoScan device. The data collected in the chain will be used to feed the DSS on Animal Welfare and the Traceability system that will use this data to generate a QR code that can be used by consumers to verify information on food traceability through a web interface.

Saving data in the blockchain means making it safe and immutable, once data is saved it is impossible to change it. The final user, thanks to the dashboard made available by DEMETER, scanning the QR code on the packaging and entering the expiry date, will be able to visualise all supply chain stages, from milking to bottling, including the collection of qualitative data.

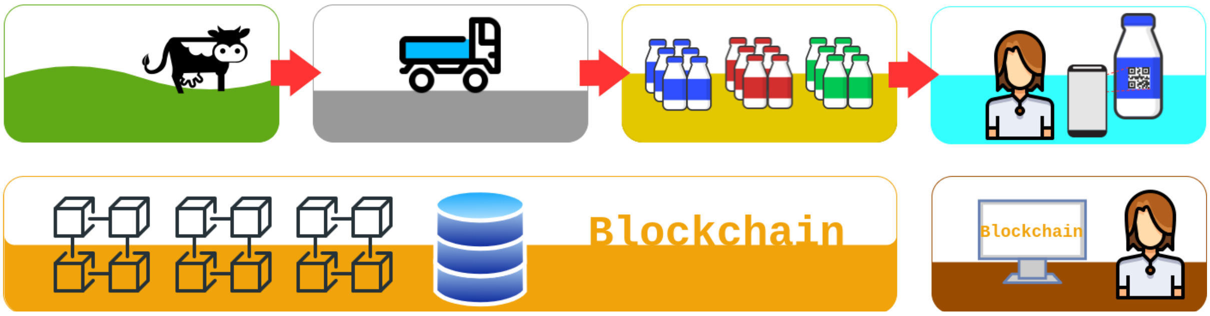

Figure 39: Pilot 4.2 – Data collection process

20.1.2 Used Data

This pilot is aimed at the optimisation of the information flow between the actors involved in the short milk supply chain. The data used are:

- Rumination, eating habits, respiration monitoring, animal rest (lactations, activity, total daily lying and many others)
- Milk quality (fat, proteins, etc.) and electrical conductivity
- Characteristics of all milk collected and fresh milk composition analysis (such as aciditySH, casein, density, fat, freezing point mC, lactose, protein, SNF, urea etc)
- Farm benchmarking data which will also include historical farm data
- User data (such as username, password, first name, surname, phone number, email address, home address, company, sectors of interest, etc.)

This pilot will model the information related to animal welfare in AIM (defined in deliverable D2.1) using FIWARE Animal data model. This data model, already defined in its characteristics in D2.1, could be extended in this pilot, in order to map data that are not currently foreseen in the model.

Furthermore, this Pilot manages general information, such as users and/or farm concepts that will be modelled in Agricultural Information Model (AIM) already defined in D2.1. Below, an example is shown (more properly related to the prediction on animal welfare), in which the AIM concepts are used to model this kind of information.

```
{
"@context" :
  {
      "predictionDate" : {
      "@id" : "https://uri.fiware.org/ns/data-models#predictionDate"
    },
    "activitiesMeasuredBy" : {
      "@id" : "https://uri.fiware.org/ns/data-models#activitiesMeasuredBy",
      "@type" : "@id"
    },
      "referredToTheAnimal" : {
      "@id" : "https://uri.fiware.org/ns/data-models#referredToTheAnimal",
      "@type" : "@id"
```

```
    },
      "mid" : {
      "@id" : "https://uri.fiware.org/ns/data-models#mid"
    },
      "lactations" : {
      "@id" : "https://uri.fiware.org/ns/data-models#lactations"
    },
      "dailyProduction" : {
      "@id" : "https://uri.fiware.org/ns/data-models#dailyProduction"
    },
      "averageDailyProduction" : {
      "@id" : "https://uri.fiware.org/ns/data-
models#averageDailyProduction"
    },
      "dailyFat" : {
      "@id" : "https://uri.fiware.org/ns/data-models#dailyFat"
    },
      "dailyProteins" : {
      "@id" : "https://uri.fiware.org/ns/data-models#dailyProteins"
    },
      "totalDailyLying" : {
      "@id" : "https://uri.fiware.org/ns/data-models#totalDailyLying"
    },
  }
}
```

Some of these concepts have already been defined in D2.1 and integrated into the AIM thanks to the re-use of specific ontologies, but others will have to be integrated in order to support specific information such as predictive models for the Animal Welfare.

20.1.3 System Extensions and Applications

The following picture corresponds to the instantiation of the Reference Architecture defined in DEMETER for pilot 4.2. It presents the mapping of the DEMETER architecture to the pilot, the delivery of apps through it and the composition of such apps from DEMETER enabled entities, data and services.

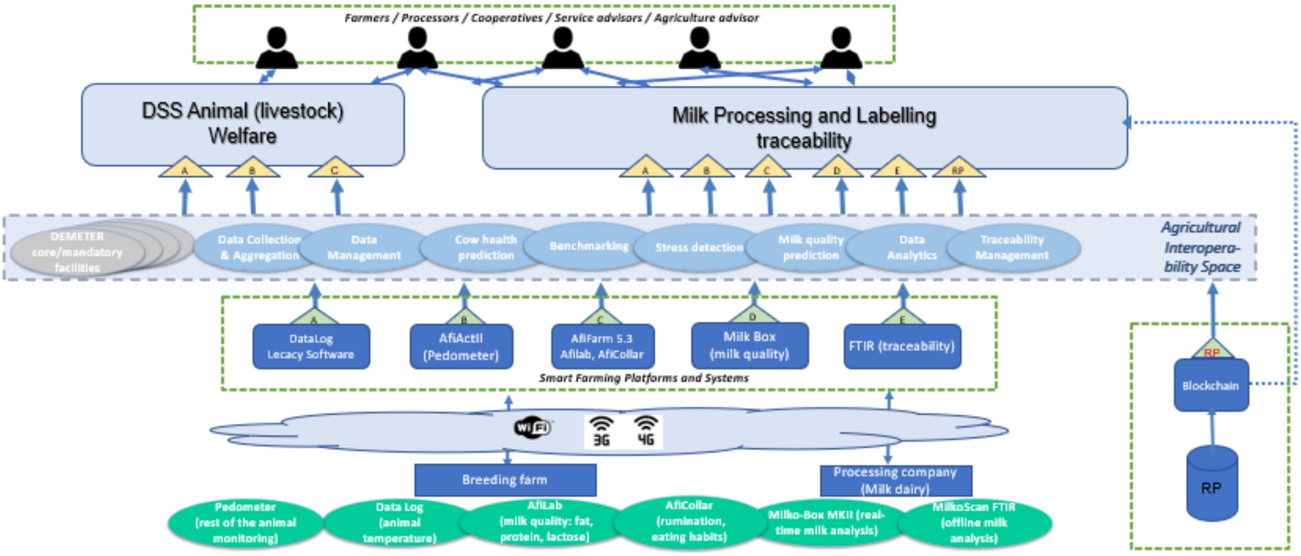

Figure 40: Pilot 4.2 Reference Architecture Instance

The raw data coming from the various devices, are presented at the bottom of the picture. They are connected through the appropriate communication protocols (WiFi, etc.) to existing Smart Farming Platforms and Systems. These systems acquire data from sensors, such as the datalog that measures the animal's internal temperature or the pedometer that records parameters relating to the movement of the animal during the day and so on, pushing them towards the farm's legacy systems. Once arrived at the servers, these data are integrated and exported according to the CSV format. The datasets thus generated feed the technological solution and therefore the DEMETER enablers. It is planned to use in this pilot all the enablers currently considered mandatory (the core enablers), to start establishing a data connection also with the DEMETER Enabler Hub, but also with the analytical components and those prepared for visualization foreseen in WP2 and WP4.

In particular, the data processed by the DEMETER enablers will then be used by the following DSSs:

- Animal Welfare DSS: gives integrated insight on animal welfare and will suggest corrective actions to the breeding farmer.
- Milk quality traceability DSS: offers to the farmer a prediction of the milk quality based on the data collected. Moreover, the DSS will provide suggestions about what to do to improve critical results.
- Benchmarking DSS: provides the farmer and the processing company with a short report showing a comparison of a set of farm's performance indicators (milk yield by cow, milk total yield, milk quality, cow health, nutrition and company productivity) with a set of target values (i.e. average and optimal indicator values from similar/neighbour companies).

Traceability system: tackles requirements for data integrity, data security and tamper resistance, exploiting distributed ledger technology to store validated data concerning production process coming from other DEMETER devices, and exposing API for retrieval of previously stored and validated information.

21 Pilot 4.3 - Proactive Milk Quality Control

Pilot 4.3 involves the integration of animal behaviour and physiological data into a welfare and health scoring framework with progression to a reference system to increase animal well-being standards on dairy cow farms.

The Pilot will be deployed in two specific locations within the island of Ireland; the initial research element will be conducted at the Teagasc Animal and Grassland research and Innovation Centre, Moorepark and the validation/ working prototype will be conducted on a commercial farm with up to 500 dairy cows.

21.1.1 Use Case Workflow

This pilot will incorporate inputs from animal welfare biomarker tests, welfare sensors and animal behavioural sensors, as well as cow farm management input and performance data.

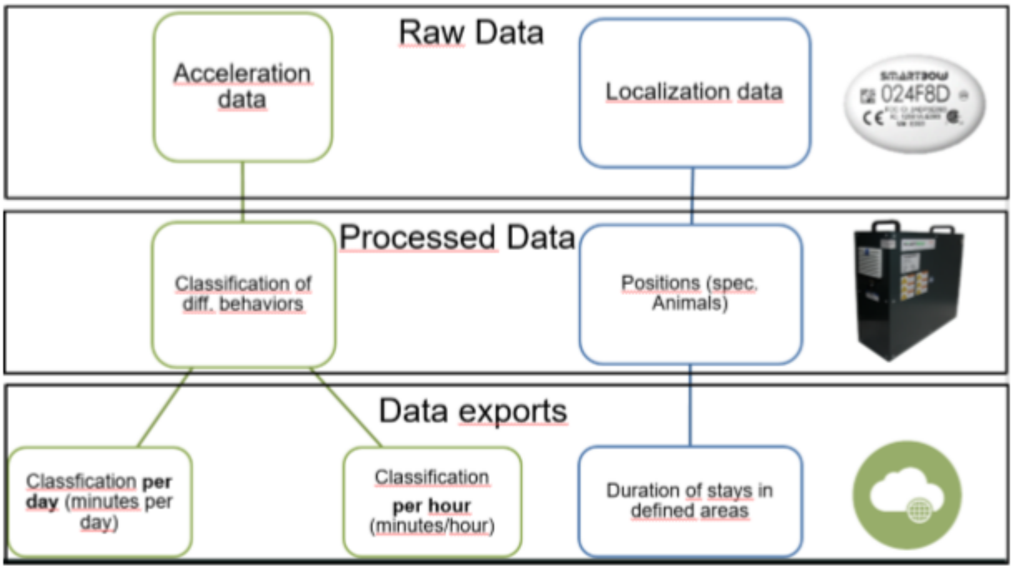

Figure 41: Data collection methodology

The data given by the sensors (=raw data) inside the SMARTBOW Ear tags is classified by special mathematic functions and then used for the calculations in form of algorithms. Those algorithms in connection with a decision function are then used to create certain alerts that are shown in the SMARTBOW user software.

The acceleration data is generated by the acceleration sensor and the localization data is generated by the funk chip (transceiver) inside the Ear tag, therefore the two types of raw data are created independently from each other. Consequently, there are no combined files including the data of both functions.

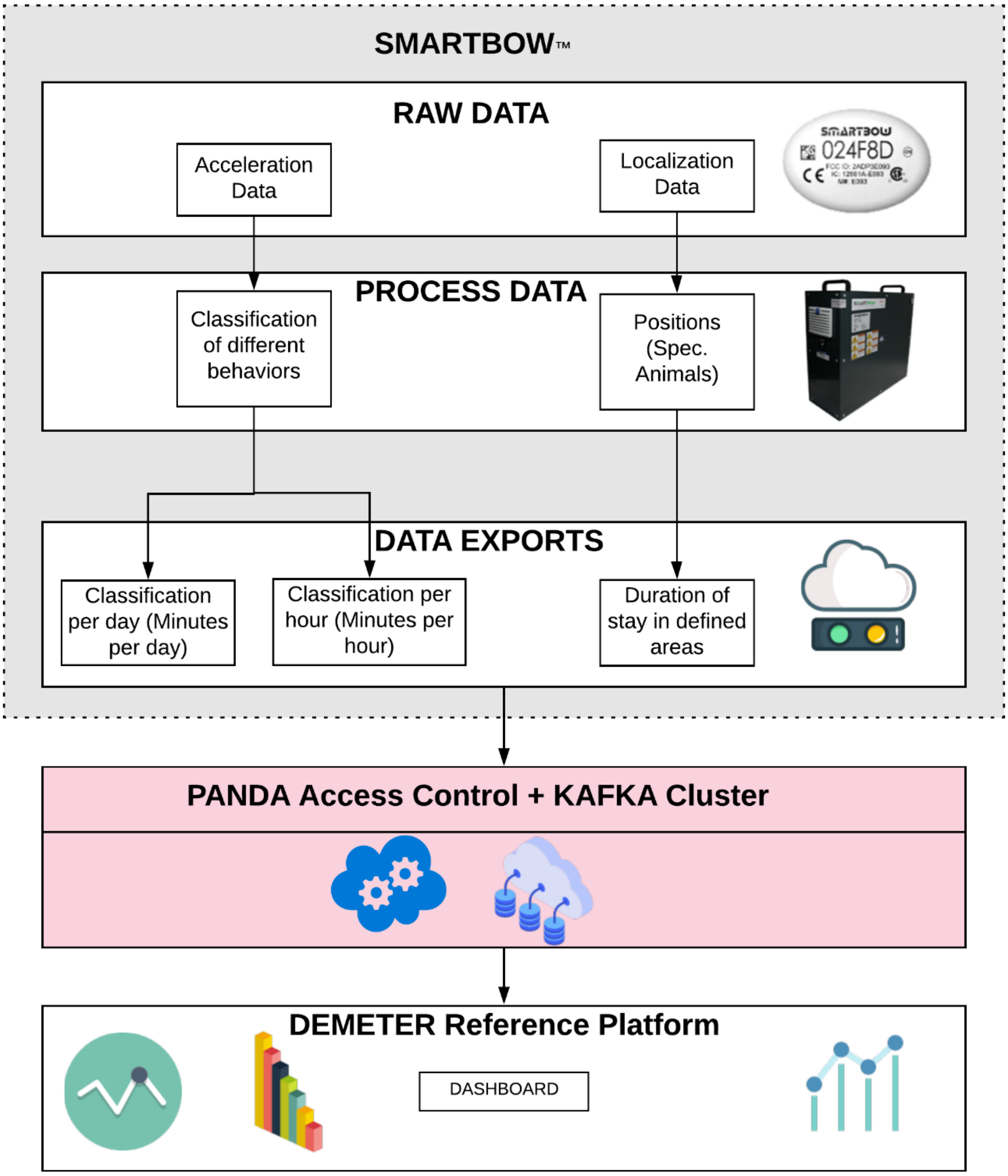

Figure 42: Data flow in pilot 4.3

Acceleration data is classified by special algorithms into the following categories:

- High active, active, inactive
- Ruminate or nothing
- Lie or stand

The output of those algorithms is defined as “processed data”.

The information about the defined behaviours is then aggregated for the SMARTBOW software and in addition for the SMARTBOW data exports (format classification per hour).

The Dashboard will be provided as an external component outside of the Core Services which will be available as SaaS (Software as a Service) and consists of the Compatibility Checker, Resource Registry Management and Discovery Management as shown in Figure 42. Dashboard functional module is in charge for User Interaction & Data Visualisation. It will allow users to login to DEH, discover, register and manage DEMETER Enablers.

Note: The complete explanation of the integration of the pilots to the DEMETER dashboard is provided in deliverable 3.1 and 3.2.

21.1.2 Used Data

- Day: Day of data recording
- Animal: Government ID + Name of the animal if applicable
- Lie: Minutes/day the animal spends lying down
- Stand: Minutes/day the animal spends standing
- Walk: Always 0 is not classified
- Ruminate: Minutes/day the animal spends with ruminating
- Nothing: Minutes/day the animal does not spend with ruminating
- Inactive: Minutes/day during which the animal is inactive
- Active: Minutes/day in which the animal is active
- HighActive: Minutes/day in which the animal is highly active

Table 2: Output classification per day export

Day	Animal	Lie	Stand	Walk	Ruminate	Nothing	Inactive	Active	Highactive
01.06.2020	US000000000000	1440	1095	0	638	802	221	894	325
01.06.2020	US000000000001	1440	734	0	484	956	302	726	412
01.06.2020	US000000000002	1440	644	0	650	790	256	858	326
01.06.2020	US000000000003	1440	716	0	482	958	352	1060	28
01.06.2020	US000000000004	345	848	0	559	881	339	758	343
01.06.2020	US000000000005	706	911	0	657	783	211	954	275

In addition to this information, more details are provided in Annex 3 – Technical specification provided by specific pilot.

Like the above data sets, we have data sets for output classification per hour, Acceleration, Positions, Area, and Breeding.

- Classification of behaviour
  - Per hour (min per our)
  - Per day (min per day)
- Acceleration: x, y z and absolute acceleration (1 file per day for all animals)
- Positions: x and y coordinates (1 file per day for all animals)
- Area export: duration of stay in defined areas (min per hour)

- Breeding export: list of breeding alerts (heat and increased activity given out by the algorithms)

21.1.3 System Extensions and Applications

The following image, Figure 43, defines to the instantiation of the Reference Architecture defined in DEMETER for pilot 4.3:

This pilot will incorporate inputs from animal welfare biomarker tests, welfare sensors and animal behavioural sensors, as well as cow farm management input and performance data. Figure 43 presents a global view of how this information is gathered. The platforms engaged include Intrasoft's data processing stack, TSSGs PANDA platform.

The raw resources (e.g. various types of devices) are presented at the bottom. They are connected through the appropriate communication protocols to existing services and systems, which have been described in the previous subsection. To make them compatible with DEMETER and to use their data and facilities they are paired with an appropriate entity (DEMETER Enabler) that will provide an Agricultural Information Model (AIM) compliant wrapper. The central part of the figure above conforms the DEH, through which all these entities are offered.

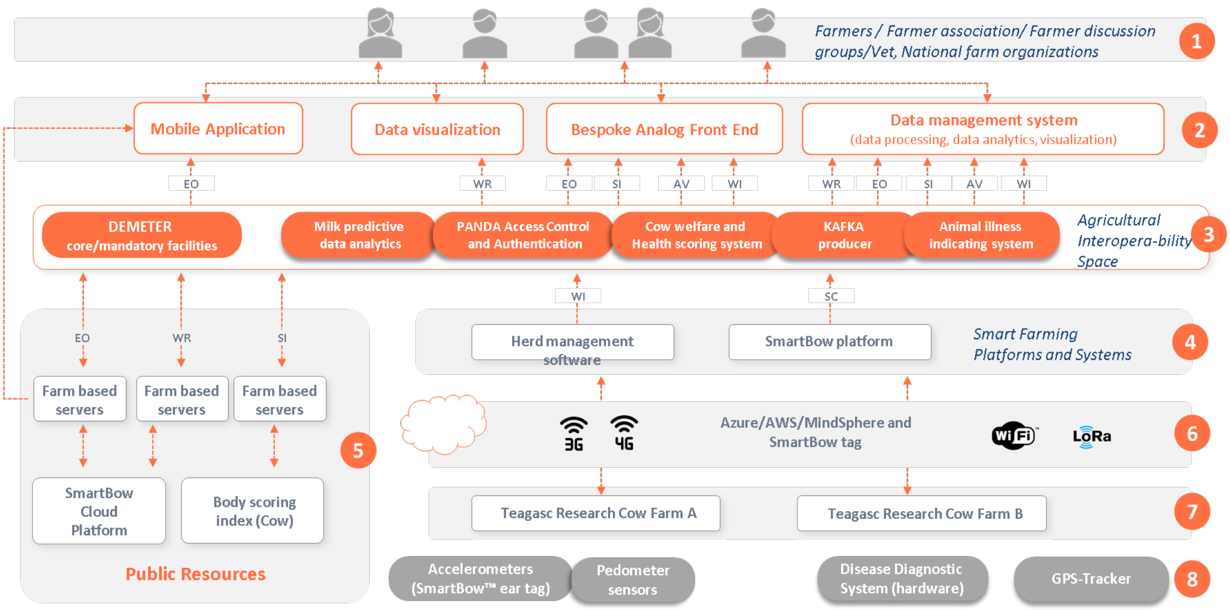

Figure 43: Global view of Pilot 4.3

22 Pilot 4.4 – Optimal Chicken Farm Management

This pilot focuses on poultry farm management, from providing guidance and support regarding biosafety and feed mixture preparation to continuous monitoring of environmental conditions, operations and animal welfare. DEMETER needs to provide an integrated management overview of the chicken production system. It must identify and provide algorithms that are able to analyse and process large amounts of data relating to the stress level monitoring for poultry farms, which will be ensured through this use case.

Devices for measuring environmental conditions (air temperature, air humidity, CO2/NH3 level) and for recording chicken behaviour and vocalization are used to collected relevant data. poultryNET platform is used as main decision support system providing advices according to gathered data analysed through embedded expert modules. Chicken vocalization and behaviour will be used for early detection of stress issues.

22.1.1 Use Case Workflow

The following image, corresponds to the use case workflow for pilot 4.4

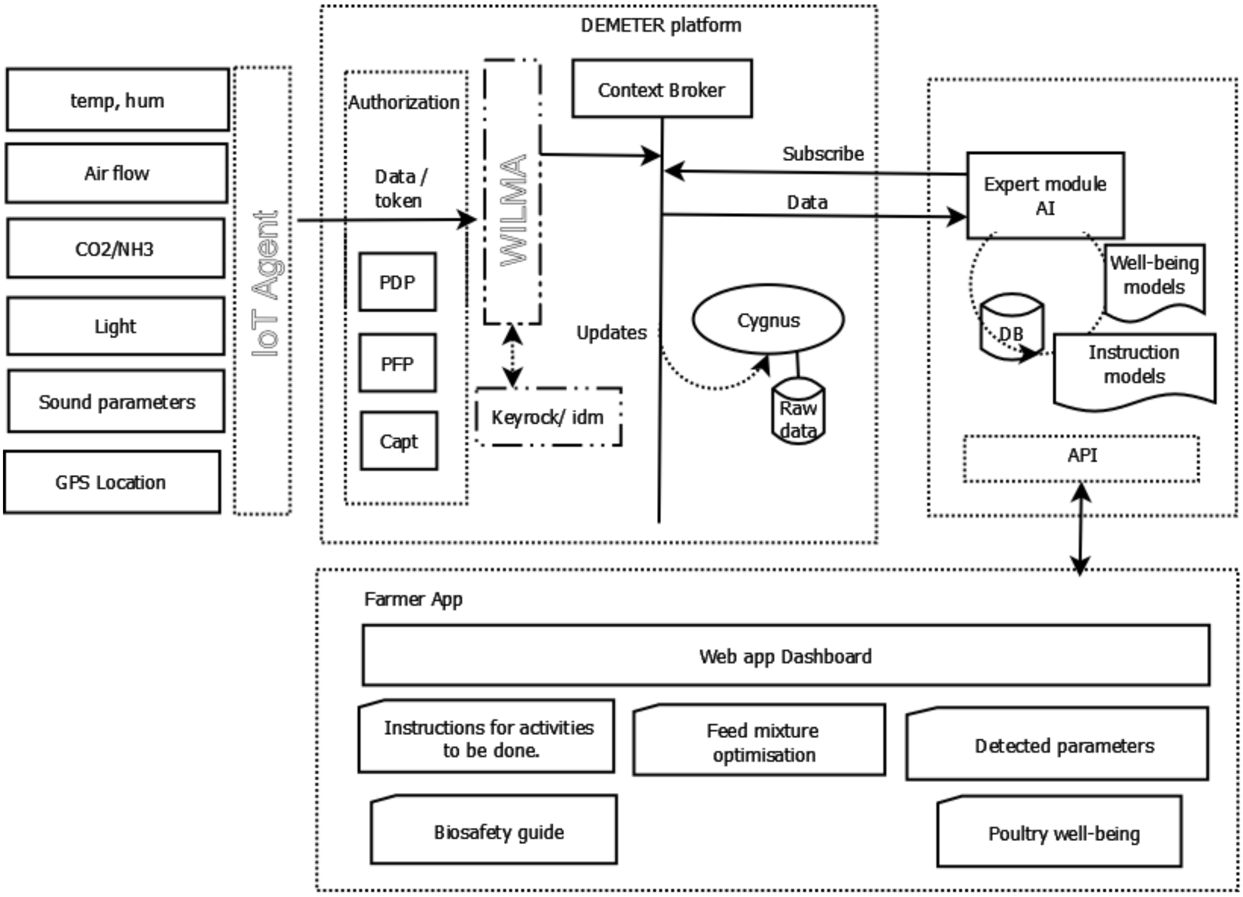

Figure 44: Use case workflow for pilot 4.4

This workflow from left to right, presents collection of the data using deployed device for measuring environmental conditions (air temperature and humidity, air flow, light intensity, CO_2 and NH_3 level), the sound parameters are extracted from the algorithms directly from the edge device, and GPS location. Measured parameters are automatically recorded in activity book. In case that parameter is not in the optimal range, the notification about possible cause of problem is created as an instruction for farmer. In case of missing some sensors (scale, food and water consumption) data should be inserted manually in the activity book (average body mass, uniformity, consumed water and food).

Expert module contains algorithms for quantification of well-being and it also generates instruction for farmers based on collected paraments and predefined models.

This module takes as an input environmental, feeding parameters and detected stress (detects directly on the edge device stress from sound parameters) and monitors current state of the production (average weight, feed conversion ratio) in order to generate to farmers instruction for activities to be undertaken. The final instructions are provided using **dashboard** application. Components are explained in more details in next section.

Part of the functionalities are available from poultryNET platform, including:

- Feed mixture optimisation: Provides recipes for the feed mixture based on the production goals (driven by market and business needs) and available food and additives, including the feed-to-food conversion efficiency models.
- Best practice and applicable regulation guide (Biosafety guide): It provides instructions and advices related to poultry farms organization, implementation of standard requirements, employee’s behaviour, chicken health management ...). Recommendations are provided for setting up production correctly.

22.1.2 Used Data

The pilot will map different data as listed below:

- Climate data in the poultry barn: Air temperature, Air humidity, Air flow, CO2/NH3 level
- Operational data: Food consumption, Power loses
- Pre and post farm activities: Feed transporting, Transport conditions (when transporting 1-day chicken), Transport conditions – cold chain

It will also use data from registered users:

- User credentials: Username, Password
- Company general information: Username, Email address, Company name, Sectors of interest

The DEMETER Enablers will ensure the secure exchange of data, the interchange mechanisms and the semantic interoperability by guaranteeing the AIM format. In particular, user credentials and geospatial information (poultry location, farm location, crop-specific information) will be directly modelled according to AIM, as defined in D2.1. Information from IoT sensors ill be remodelled via AIM-compliant wrappers. Information provided by edge cameras deployed on field, with data about well-being: parameters from sound, power and travel assessment will be processed internally and adapted and integrated into the AIM facilitating adapters for specific ontologies related to livestock features, alerts, properties and systems.

22.1.3 System Extensions and Applications

Figure 45 presents a view of the DEMETER architecture of the pilot together with the services to be delivered through DEMETER and its composition of such services over DEMETER architecture.

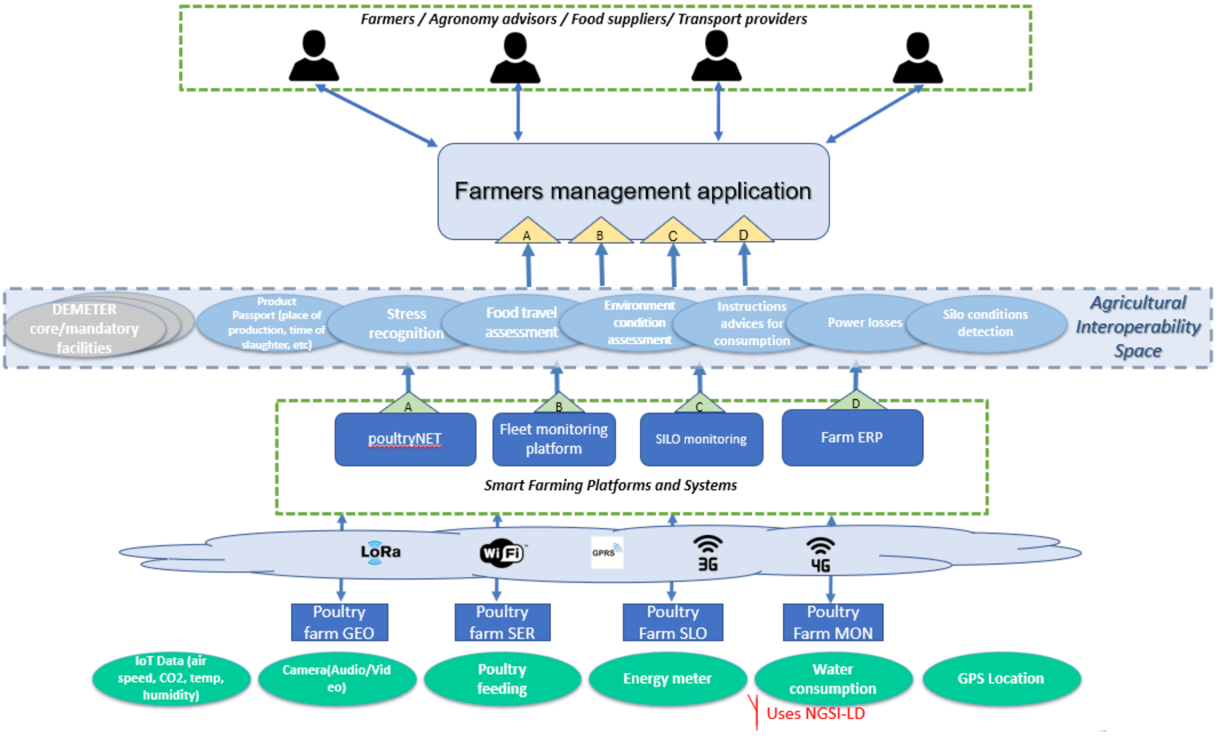

Figure 45: Instance of DEMETER reference architecture for pilot 4.4

The raw resources (e.g. various types of sensors and devices) are presented at the bottom. They are connected through the appropriate communication protocols (LoRa, WiFi, etc.) to existing Farming Management Information Systems (FMIS) or IoT Device Platforms. In this pilot we can find:

- poultryNET farm system: expert system for detection of environmental parameters on farm with instruction for farmers
- Silo monitoring service: detection of amount of food in silo using radar sensor
- Farm ERP: Internal farmers system (not available on all farms)

To make them compatible with DEMETER and to use their data and facilities they are paired with an appropriate entity (DEMETER Enabler) that will provide an AIM compliant wrapper. The central part of the figure above conforms the DEH through which all these entities are offered. On the left, we find DEMETER mandatory entities (grey) to be used by the optional ones (blue) needed by this pilot represents subcomponents of the Expert module:

- Product passport: Component that provides all relevant product information (place of production, time of production, poultry health, etc)
- Stress recognition: This component is assessing the parameters detected from sound to recognize parameters that could indicate stress on a farm
- Instructions and advices for consumption: instruction added directly fitting to the required models used for assessment based on input parameters
- Power loses component detect power loses to indicate this parameter for the chicken stress
- Silo condition detection**:** This component detects amount of food in the silo using the radar senor

These enablers offered by the DEH are used to compose the DEMETER Enabled Applications for the business solutions of the pilot that are presented at the top of the figure with the application that provides decision support system in form of an instructions for farmers.

23 Pilot 5.1 - Disease Prediction and Supply Chain Transparency for Orchards/Vineyards

Pilot 5.1 aims at improving the production in orchards/vineyards by providing decision support in pest and disease management. In addition, another objective of this pilot is to evaluate and validate technical aspects of creating a product passport for the fruit and wine products as the basis for creation of a transparent and trusted supply chain. For this purpose, this pilot collects environmental data which is used as input in pest and disease prediction models which are later used to generate advices and instructions to the farmers.

The product passport platform will gather relevant information from different farm management platforms about the supply chain activities (production, transport, retail), relying on interoperability interfaces defined by DEMETER. This way, the pilot will investigate the required granularity of data to be collected, its lifespan, as well as technical implications of processing such potentially large amounts of data. A blockchain-based data exchange protocol (OriginTrail) will be used to ensure trust and transparency between actors in the value chain.

In order to achieve this goal, the deployment and installation of this pilot included devices for measuring environmental parameters (air temperature, air humidity, rainfall, leaf wetness, radiation, wind speed); as well as data about the crop (Crop type and planting date). The installation was done in 14 vineyards (more than 2500 ha) and 3 apple orchards (around 30 ha) in the following countries: Georgia, Slovenia, Montenegro and Serbia.

23.1.1 Use Case Workflow

The following image presents the integration of Pilot 5.1 in the DEMETER environment providing specific details regarding the flow of information among its components.

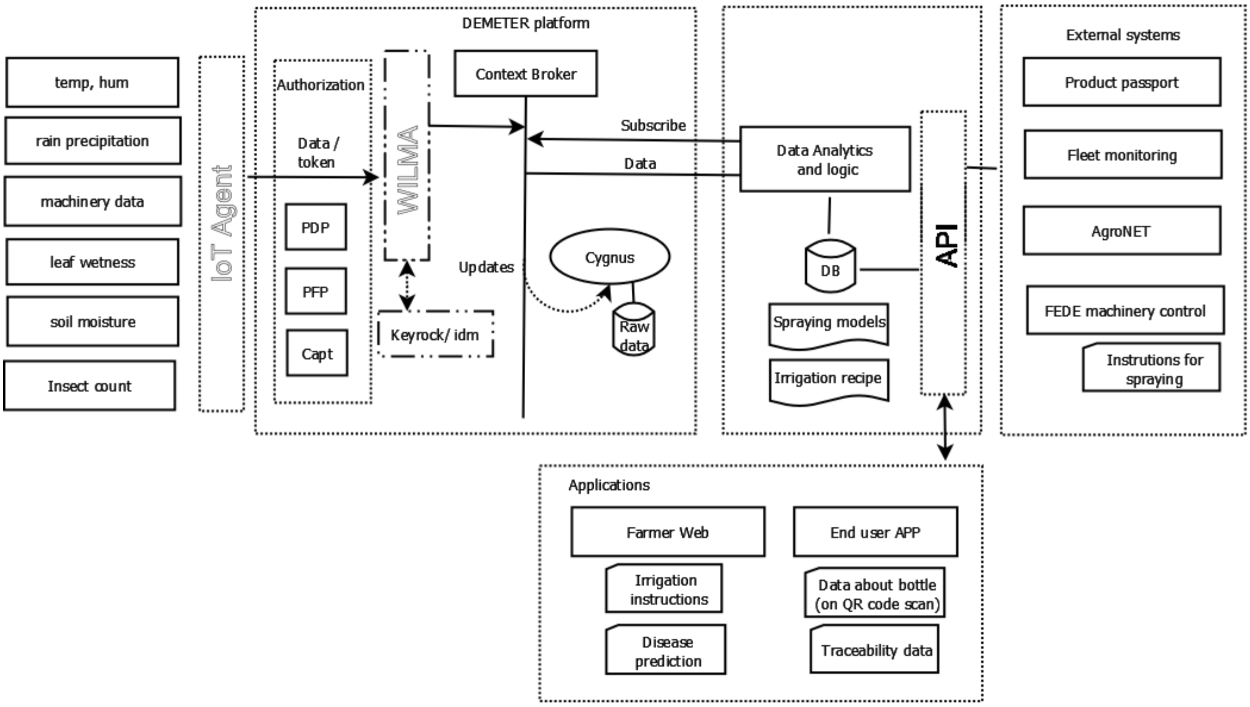

Figure 46: Pilot 5.1 information flow diagram

The pilot has following components and extensions:

- IoT Devices: for collecting various data from the field (temperature, humidity, rain perception, machinery data, leaf wetness, soil moisture, insect count)
- agroNET platform - agriculture platform for monitoring on parameters in field using sensors (temperature, humidity, rain perception leaf wetness, soil moisture), pheromone traps with cameras to detect number of insects, advanced algorithms for providing instructions to farmers
- Product Passport - platform for generation of unique item-levels identifiers used on each separate product based on GS1 digital link standard. The product passport platform has its end user application with the ability to scan each tag on product and providing traceability information to the consumer
- FEDE Machinery control exercised by Fede *Specialty Crops Platform* (SCP) that links via GPRS to the tractors and sprayers in the field.
- FleetNET platform - fleet monitoring platform for tracking of vehicles GPS location, and collection of various statistics for vehicle over the CAN interface
- Farmers and end user application: to provide data about irrigation instructions, disease prediction as well as data about product’s authenticity and proof of origin together with the usual information about the products

23.1.2 Used Data

The pilot produces crop water status and irrigation requirements at a daily time step, as well as temporal patterns of soil moisture level. The pilot will use/produce different data as listed below:

- Quality of the Environment and control: Atmospheric temperature, humidity, rain precipitation, connected sprayer (with speed, activity), leaf wetness, soil moisture
- Product Passport Data: Production place, environment data, time of harvest, disease model, storage, transport condition provided by different devices, platforms and systems, unique item-level identification provided by product passport platform based on GS1 digital link standard, product passport dependency
- Disease prediction: Crop type, prediction model for specific pest/disease, number of insects (counted using AI), instructions for machinery
- Operation of machinery: Monitoring of tractor and sprayers provided by FEDE machinery control, ISOBUS protocol/ csv format
- Product Location: GPS location data of the products provided by GPS sensors connected to fleet monitoring system, provided in JSON format, 3G/4G interface, fleet monitoring platform dependency
- Area data: Latitude, longitude

It will also use data from registered users:

- Company credentials: Username, Password, Company name

The DEMETER Enablers will ensure the secure exchange of data, the interchange mechanisms and the semantic interoperability by guaranteeing the AIM format. In particular, user credentials and geospatial information (location, farm boundaries, crop-specific information) will be directly modelled according to AIM, as defined in D2.1. Information from IoT sensors and weather station will be remodelled via AIM-compliant wrappers. Information provided by devices deployed on field and data about the soil that are used for formulation of the watering recipe together with the data about humidity, temperature, etc. This information will be processed internally and adapted and integrated into the AIM facilitating adapters for specific ontologies related to agriculture features, crops, alerts, properties and systems.

23.1.3 System Extensions and Applications

The following figure presents the instance of the DEMETER reference architecture for Pilot 5.1. The raw resources (e.g. various types of sensors and devices) are presented at the bottom. They are connected through the appropriate communication protocols (LoRa, MQTT, 3G, WiFi, etc.) to existing agroNET and fleetNET solutions. Other external systems are also used to enable product passport data (Product passport platform) and control of the FEDE sprayers (FEDE Machinery control).

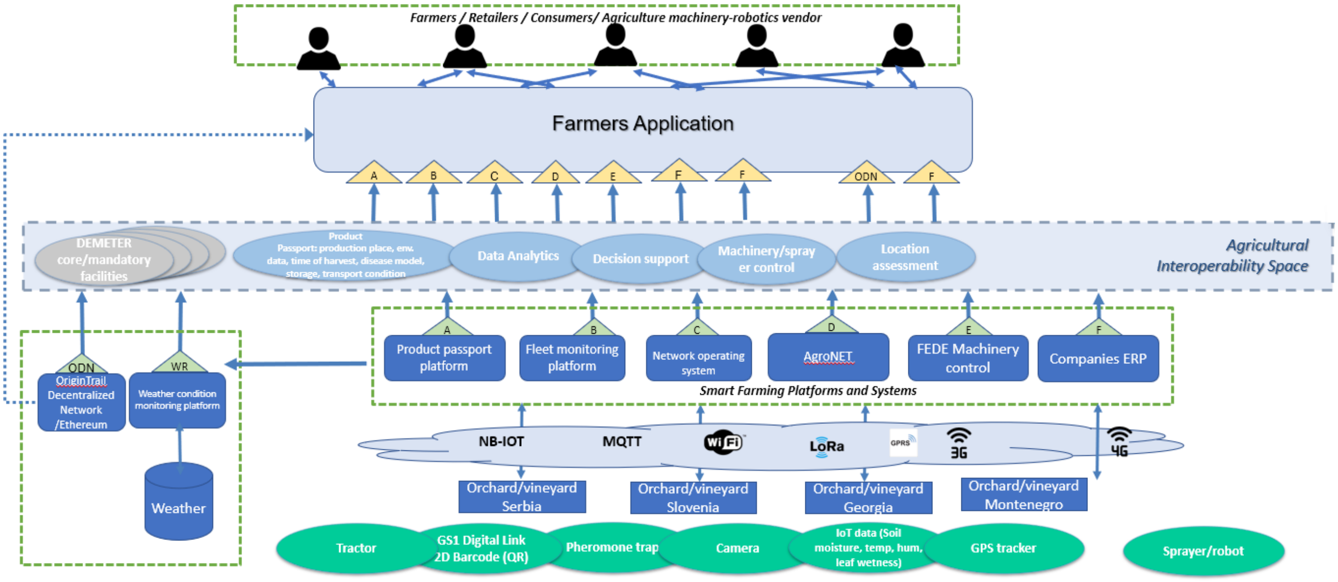

Figure 47: Pilot 5.1 instance of DEMETER reference architecture

The use case components will be made compatible with Demeter to be able to use the data and facilities paired with an appropriate entity (Demeter Enabler) that will provide an AIM compliant wrapper. The central part of the figure above conforms the DEH through which all these entities are offered. On the left, we find Demeter mandatory entities (grey) to be used by the optional ones (blue) needed by this pilot are:

- Product passport: Component that provides all relevant product information (place of production, time of production, poultry health, etc)
- Decision support and data analytic: these components contain prediction models that provides information on pests and disease appearance according to their life cycle and plant growing period. Combining those models with acquired environmental data, data analytic generates information on how to react in order to avoid insect overpopulation or a spread of diseases.
- Machinery sprayer control: This component makes instructions for the FEDE machinery that provides all relevant information for spraying which will be triggered by the FEDE *Specialty CropsPlatform* (SCP)
- Location assessment: Component that provides assessment of the location of the product including parameters collected at the time that influence product quality

24 Pilot 5.2 - Farm of Things in Extensive Cattle Holdings

Pilot 5.2 focuses on improving milk quality in dairies as well as animals' well-being and health, and how this can affect the quality and information of processed products, considering also cereals and eggs as raw materials. This pilot also considers end-user involvement in quality testing and feedback provision.

Three use cases will be developed in this project:

- UC#1: Ensuring the optimal feeding of cows by managing animal wellness and measuring crops and soil properties (irrigation, need for fertilising).

- UC#2: Improve the production management in a livestock farm integrating new technologies into the daily operations.
- UC#3: The food transparency and user involvement use case intends to integrate data brokering solutions in current production systems of dairy products and pastries.

24.1.1 Use Case Workflow

For this pilot we consider as inputs: data provided by sensor networks deployed in the fields, field data collected by robotic devices (i.e. UGVs), animal identification data from RFID devices and data from external repositories (e.g. the AFarCloud repository, milk data, environmental data, product database or satellite imagery for map cartography).

Pilot's components will be integrated with the DEMETER Reference Platform comprised by the DEMETER SOCS, DEH, Dashboard and BSE. Figure 48 represents how the platforms to be used in this pilot (i.e. AFarCloud Middleware, Farm Proxy and Data Management & Monitoring) are integrated within the BSE of the DEMETER reference architecture. In this way data exchange with other platforms is ensured.

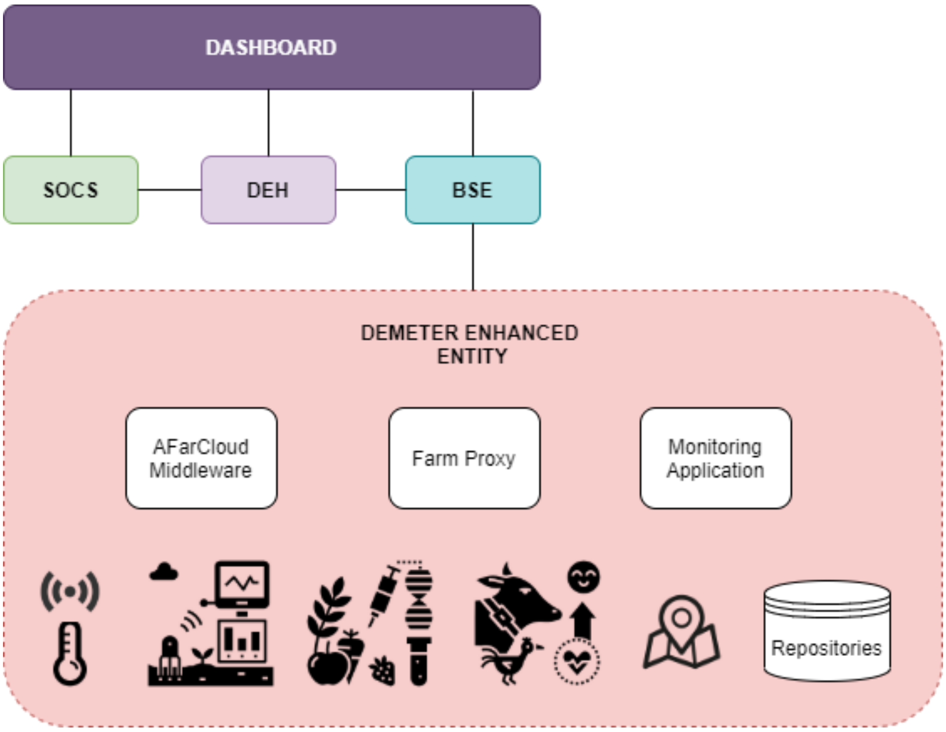

Figure 48: Example of pilot 5.2 flow of information

Data acquisition for the Smart Farming platforms of pilot 5.2 is done through standard protocols such MQTT, OGC, REST, DDS (Data Distribution Service) or RFID.

24.1.2 Used Data

This pilot is aimed at the optimization of the production costs, the improvement of product quality, the animal welfare, the food traceability and the increase of final user-involvement. For this reason, the pilot will manage the following data types:

- Soil, UGV (e.g. images), environmental, geospatial, satellite and milk data will be used to detect the best moment for harvesting, so that the silage characteristics are the optimal for improving dairy quality. Moreover, the gathered data from the milk characteristics become the necessary feedback for improving the whole process, as a control closed loop.
- Animal data: information that identifies an animal and some important information related to his health. Provide by farmers and updated by vets.
- Farm data: information that identifies a farm and his social information. Provide by farmers.
- Product data: quality and sustainability information (i.e., Combination of public information of products and other data provided by production companies).
- Final user feedback: Information produced by end-users or costumers in relation to the evaluation of the users of the attributes of quality and sustainability of the products, and the recommendations made, lists of favourite products, etc.

The farms involved in the pilot have a varied level of automation tools in use. However, in most cases, these tools are independent of each other and no integrated view is available. The pilot deployments will integrate the existing systems as much as possible (depending on the features of the tools) and will deploy new edge devices to provide the required functionality. In the case of the production system, the current production control system will be improved by providing extended information and consumer's feedback.

This information is modelled thanks to the AIM already defined in Deliverable 2.1 through the AgriFood Data Model. The AIM will be used to format part of the data to be used in this Pilot, like the data related to time, geographic information, animal welfare, soil conditions and product information, and also the application domain-specific ontologies will be used.

The following profiles related to this Pilot are identified: *agriProperty*, *agriProduct*, and *farmAnimal* modules, related to the following domain-specific ontologies:

- Agriculture Properties ontology: available under https://w3id.org/demeter/agri/agriProperty
- Agriculture Product ontology: available under https://w3id.org/demeter/agri/agriProduct
- Farm Animals ontology: available under https://w3id.org/demeter/agri/farmAnimal

24.1.3 System Extensions and Applications

The following image, Figure 49, corresponds to the instantiation of the Reference Architecture defined in DEMETER for pilot 5.2:

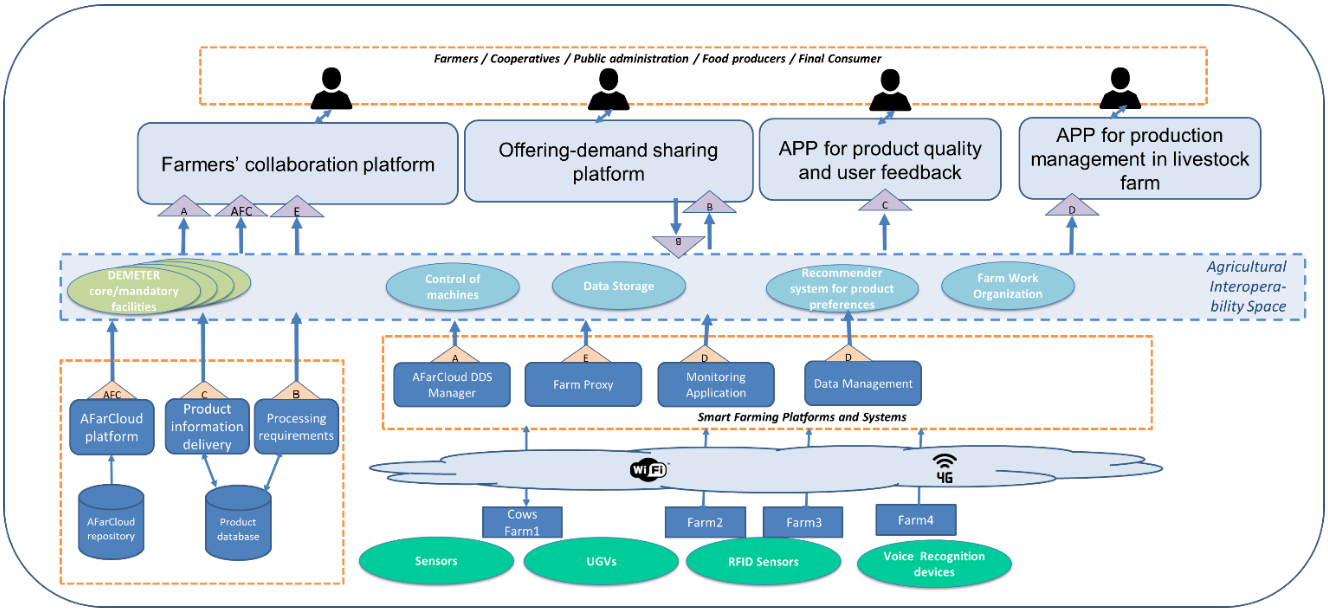

Figure 49: Reference architecture instantiated for Pilot 5.2

This figure presents the mapping of the DEMETER architecture to the pilot, the delivery of apps through it and the composition of such apps from DEMETER enabled entities, data and services.

The raw resources (e.g. various types of devices) are presented at the bottom. They are connected through appropriate communication protocols (i.e. 4G, WiFi, etc.) or existing Farming Management Information Systems (FMIS) or IoT Device Platforms. In this pilot we can find:

- AFarCloud Middleware: Imported from the H2020 ECSEL project AFarCloud, this middleware provides different interfaces to allow exchange of messages between hardware devices and vehicles. The main components of the AFarCloud Middleware are listed below:
  - The DDS Manager provides a DDS interface to allow the exchange of real-time messages with unmanned vehicles.
  - The MQTT Broker offers a MQTT interface for exchanging messages with MQTT compatible devices (e.g., sensors and actuators).
  - The OGC Converter enables interoperability between the AFarCloud Middleware and OGC compliant data sources.
  - The REST Server offers REST services for collecting measurements and observations from hardware devices.
  - The AFarCloud Cloud Repositories store data in 3 types of repositories (semantic, relational and NoSQL), depending on the needs of the information to be stored.
- Farm Proxy: It provides an abstraction layer dedicated to hide specific details of a farm so that interaction between DEMETER and any farm in the use cases can be easier, and by homogeneous interfaces.
- Monitoring application: Component that will show the values of some measurements that can be used to determine if an animal has a health problem. It can send different kind of alerts to report these notifications.

To make them compatible with DEMETER and to use their data and facilities they are paired with appropriate DEMETER enablers that will provide an AIM compliant wrapper. The central part of the figure above conforms the DEH through which all these entities are offered. The entities that we can be found in this pilot are:

- Control of machines: This component will provide a DDS interface to allow the exchange of DDS messages with unmanned vehicles. By means of this interface, this component will be able to send actions to vehicles, to collect the status of these actions and to collect data from sensors onboard vehicles.
- Data storage: This component will provide mechanisms to insert, consult or update any information from the repositories. The component will provide the needed interfaces to the hardware layer for data storage, and to the service layer for data retrieval.
- Farm work organization: This component will enable veterinarians and farmers to manage and make decisions in their livestock farms through advanced applications of animal identification and control, making use of technologies such as RFID and voice recognition.
- Recommender System for product preferences: This system establishes contacts between consumers and shares among them lists of products that will be stored in their respective profiles. A valuation system according to various criteria (labelling, sustainability, detail in the information) will enable this recommender system to offer products in the form of automatic recommendations to users according to their profiles.

These enablers offered by the DEH are used to compose the DEMETER Enabled Applications for the business solutions of the pilot that are presented at the top of the figure:

- Farmers collaboration platform: This platform provides some tools in the form of a small ecosystem in which farmers have the necessary functionalities to share results, resources, experiences and so forth.
- Offering-demand sharing platform: Creation of a marketplace with a web interface that allows different companies to register requests and offers for products or ingredients. The web application should allow a company, for example a food producer, to launch requests on the type of ingredients it needs (flour, oil) and other companies or farmers that produce these ingredients, to be able to accept these requests, or to launch their own requests for a negotiation, according to requirements of product quality, volume, price, etc.
- APP for product quality and user feedback: This application shows end consumers a capacity to search for products and ingredients according to information from open databases, with special attention to sustainability information (stamps and consumer guarantees). It offers consumers the possibility of evaluating the information provided and sharing these evaluations among all users of that App.
- APP for production management in livestock farm: This application will allow vets and farmers to check the status of their livestock and check if some results from different test records have strange values. Vets will be able to visualize this information on AR glasses so they can work more comfortably.

25 Pilot 5.3 - Pollination Optimisation in Apiculture

Pilot 5.3 aims to develop and provide service for pollination optimization. The service will connect farm management system with apiary managements system with advisory and decision support services. The goal of the integration of different agriculture systems is to enable a better communication of farmers and beekeepers, to protect bees and to optimise pollination of crops with the aim of improving their yields.

In particular, in the pilot we will connect the farm management systems, eDWIN Virtual Farm in the pilot created by the regional agriculture advisory centre (WODR), and apiary management systems, ControlBee in the pilot (IDEATROINK) and DEMETER DSS services to manage beekeeping information, including apiaries and farming activities like planned fertilizations (based on the information from farmers), and to provide new advisory services.

Existing systems will be improved with new functionality, enabling the collaboration scenario without the need of using new system. Moreover, as part of the project existing sensors will be improved, and new apiary sensors are developed to allow remote monitoring of mobile apiaries.

The pilot involves four beekeepers and three farmers for the testing and validation and will be trialled and validated on arable crops in Wielkopolska region in Poland.

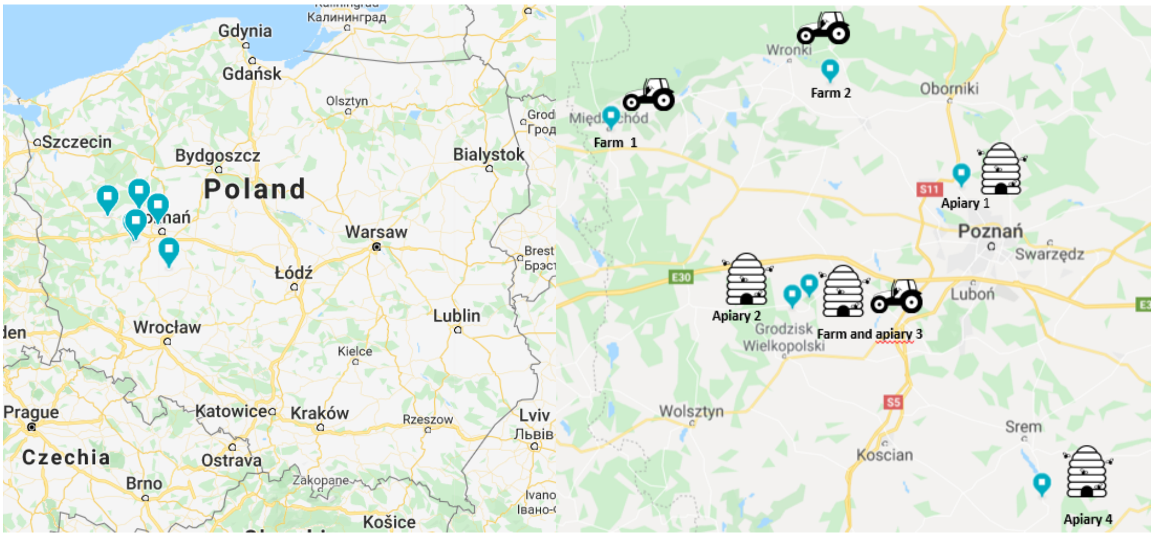

Figure 50: Pilot 5.3 testbed deployment plan

25.1.1 Use Case Workflow

This pilot is focused on the exchange of pollination related data and information between farm management systems (e.g. eDWIN in the pilot) and apiary management systems (eg. ControlBee in the pilot). It will develop a pollination optimization service to exchange information and get in touch with each other. The objective is not to provide another application or portal, but to offer a mechanism that supports the exchange of the relevant information between existing applications. Moreover, it introduces new technologies to support the beekeeper in managing hives.

The next diagram presents an example message flow between the systems for pollination matching scenario.

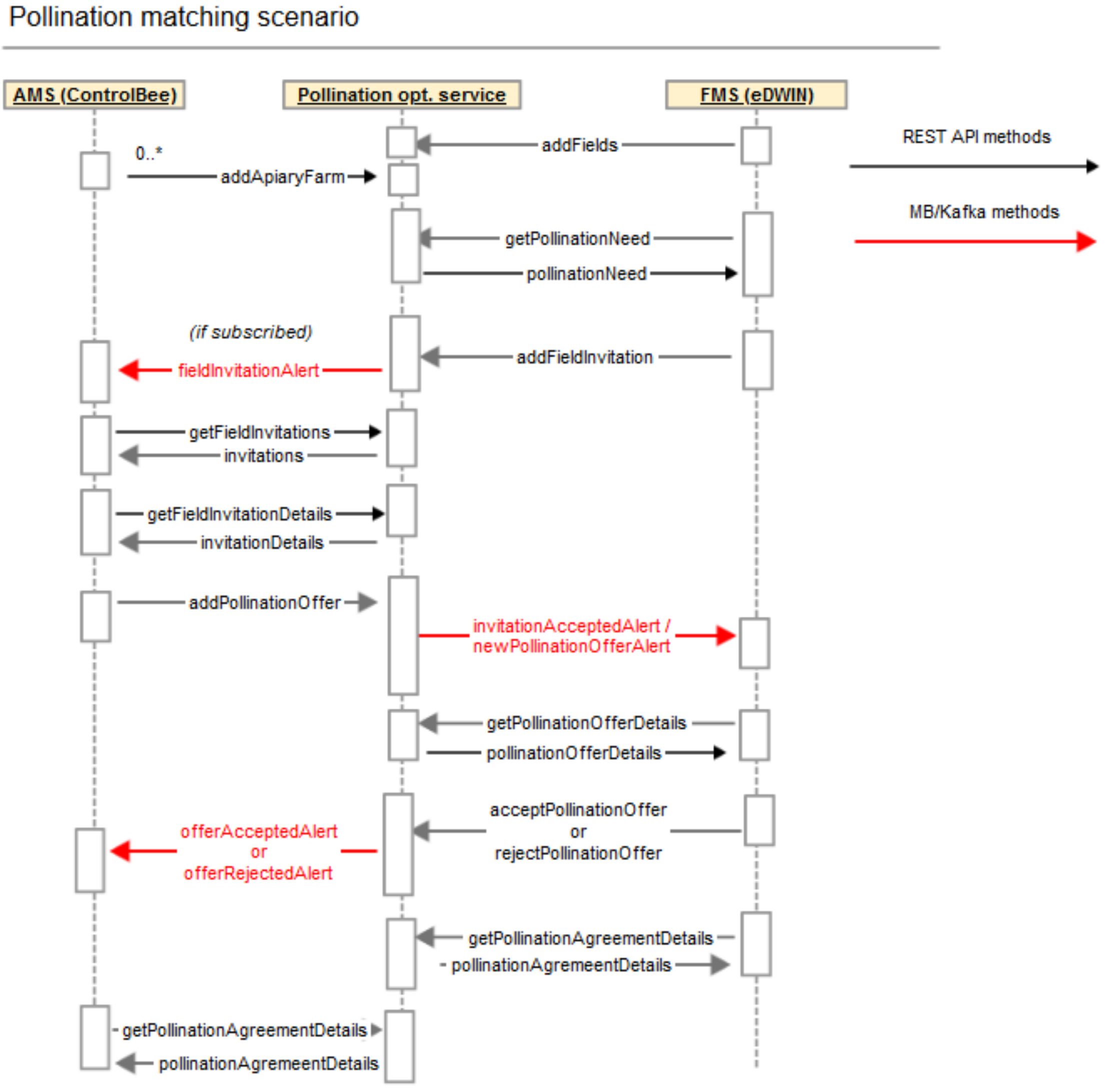

Figure 51: Example workflow diagram for the pollination optimisation scenario

The next figure presents the architecture draft for the exchange of data between apiary management system and farm management systems via the pollination optimization service:

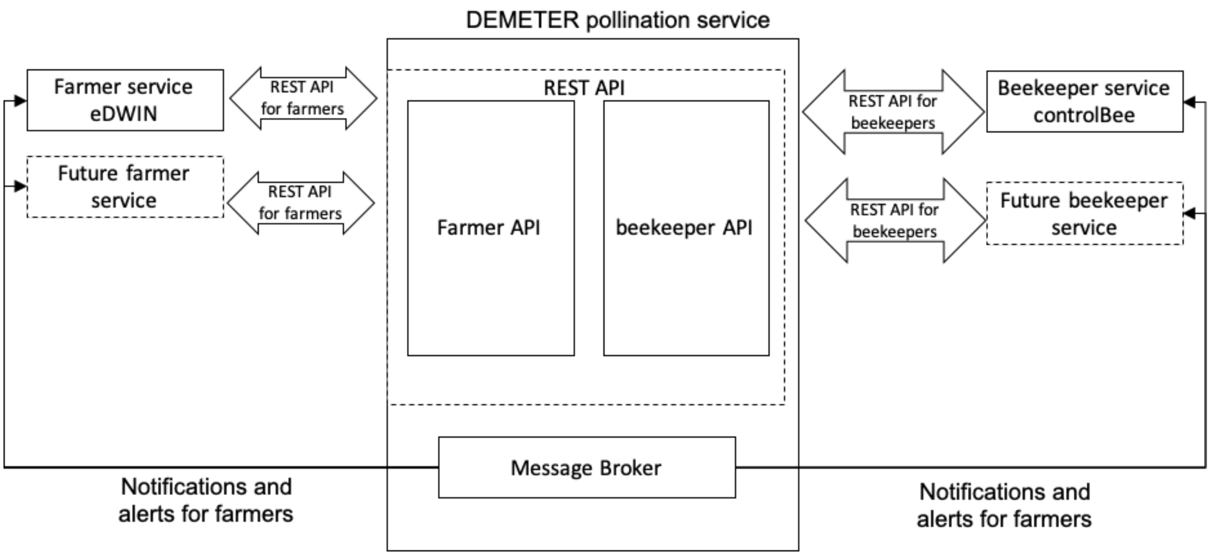

Figure 52: Architecture draft for the exchange of data between systems in the pilot 5.3

The pollination service is based on client-service architecture with the use of asynchronous messaging mechanisms. The service provides a dedicated API for its clients in a form of REST endpoints and asynchronous messaging subsystem. REST API is foreseen as the main channel and is split into dedicated APIs for farmers and beekeepers. REST API provides mechanisms for:

- User accounts registration and management – allows to register new users (farmers, beekeepers) and manage their accounts (personal data details, settings) during its lifecycle,
- Field and pollination invitations registration – allows farmers to register fields and provide data such a location, geometry, crop type. Registered fields will be used for creation of an invitation to beekeepers.
- Access to pollination services and offers making – allows users to manage pollination offers: beekeepers are able to create offers; farmers can view, accept or reject offers.
- Sprays alerting management – enables tools for alerting beekeepers about spraying procedures on fields, which may be harmful to bees.
- Private messaging mechanisms – provide tools enabling private contact between users of pollination service, mainly between farmers and beekeepers.

Asynchronous messaging subsystem is foreseen as a tool to exchange notifications and alerts between users cooperated with pollination service. Such notifications may be related for example to operations status changes or to events which may be important for the service users. Such events will be grouped into logical channels (topics) and shared with external clients. So far, the following types of notifications and alerts has been identified:

- New invitations and offers notifications, changes of invitations or offers,
- Offers acceptance or rejection,
- Field spraying alerts,
- Weather anomalies alerts.

Notifications generation processes will be personalized based on users' preferences; thus, only users interested in particular information will be notified. The use of the message broker enables easy extension notification mechanism in the future depending on service and users' needs. It is foreseen to use Apache Kafka[12] in the role of message broker, but it could be replaced by any other message broker, especially if it will be provided by DEMETER platform. Currently, every single service willing to cooperate with a pollination service (like eDWIN, ControlBee) will have to implement Kafka consumer mechanisms in order to consume messages from particular topics.

The systems involved in the pilot are the following:

1. *ControlBee (Apiary monitoring/management system)*

ControlBee[13] is a dedicated IoT solution for beekeepers. The project is based on a network of distributed sensors that collect information about the physical conditions of beehives. ControlBee also provides geographic location information for apiaries. Below a few example mockups of ControlBee screens implementing the pollination scenario is presented.

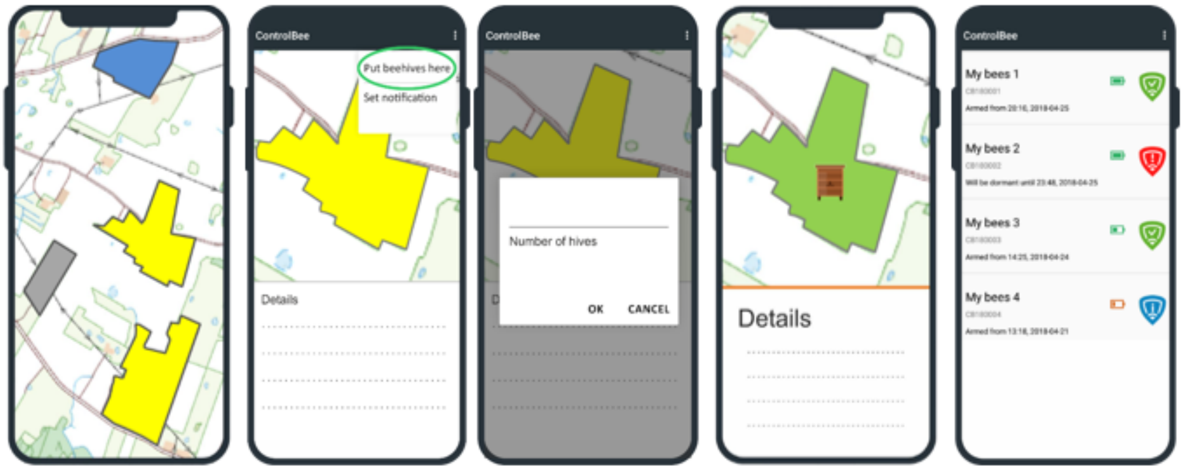

Figure 53: Example mockups of ControlBee views implementing the pollination scenario

The pilot will use the data from the following ControlBee IoT devices:

- Control unit - provides communication with the wireless sensors that are installed in the apiary. The central unit provides wireless range with the sensors up to 150 meters. The central unit is powered by a built-in lithium-ion battery. It can work continuously for up to 3 months on one charge. The central unit communicates with the ControlBee application server. The central unit has a built-in GNSS receiver to determine the geographical position where the apiary is located.
- Hive sensor - a small electronic device powered by a battery. The sensor measures the temperature in the hive and detects vibrations and shocks. The sensor communicates wirelessly with the central unit. The battery in the sensor is designed for at least 1 year of operation. Currently, work is underway on another version of the sensor, which will

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[12] Apache Kafka: https://kafka.apache.org/

[13] ControlBee: https://controlbee.pl/

additionally have an air humidity measurement and a MEMS acoustic microphone to monitor the condition of the hive.

- Hive scale - The hive scale collects information about hive weight. Small and lightweight apiary scale. It has a clear OLED display and a built-in lithium-ion battery. The scale remembers daily and hourly measurements. It works for up to 12 months without the need to charge the battery. It is very easy to assemble and use. When placed under the hive, it is not visible. The scale communicates wirelessly with the central unit.

Figure 54: ControlBee sensors and devices to be used in the pilot.

The picture below shows the architecture of the IoT apiary management system diagram. The central unit is responsible for communication with sensors in the wireless local network. The local network works in the 2.4 GHz ISM band. The physical frame format is IEEE802.15.4 compliant. Local wireless communication is encrypted using the AES protocol. The central unit communicates with the application in the WAN network via the Internet provided by mobile network operators. The central unit communicates with the server application using the REST API.

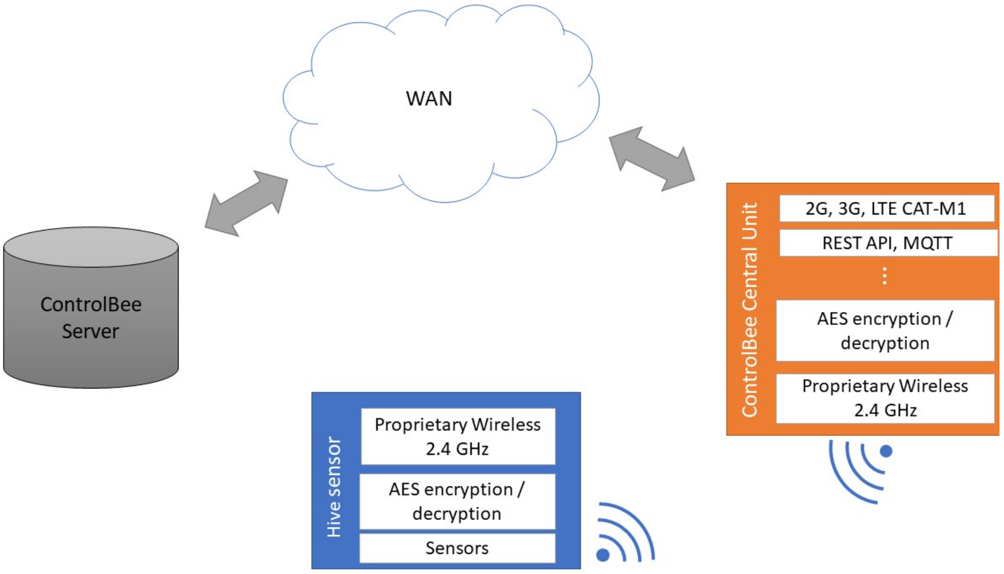


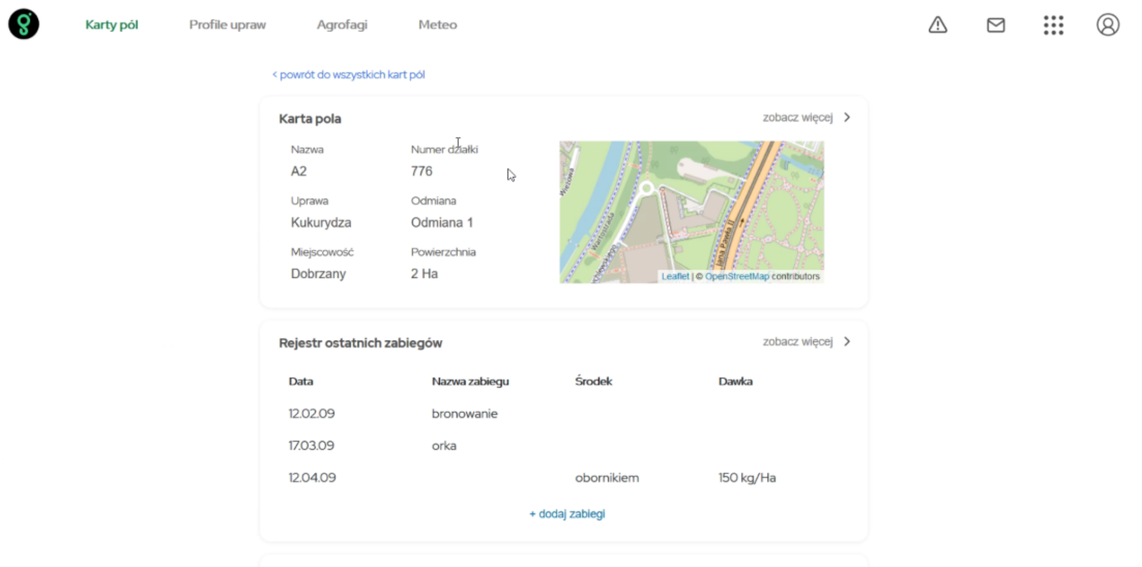
Figure 55: Architecture of the IoT apiary management system diagram

2. *eDWIN Virtual Farm (farm management system)*

The Online Consulting and Decision Support Platform in Integrated Plant Protection (eDWIN) is a project that develops a Polish national IT system for plant protection and will be a work tool for farmers and food consumers. Data provided under the system will also be used by public institutions, and scientific units, to carry out their own tasks in the field of plant protection. The system will be used to provide e-services by the Agricultural Advisory Centers. The project is implemented in a partnership consisting of a total of 19 units, and the leading partner is the Wielkopolska Agricultural Advisory Center in Poznan. Poznan Supercomputing and Networking Centre is a technical partner of the project, responsible for the development of the platform. eDWIN reuses results of a previous project, the Electronic Platform for the Provision of Services (EPSU), also developed by WODR and PSNC.

An important element of the project is the comprehensive use of existing databases currently located in distributed and autonomous systems of various institutions. Gathering many local data sources in one system will be the optimal solution affecting interdisciplinarity, credibility and certainty of information shared by eDWIN in the future. The project also envisages the construction of a national network of agrometeorological stations - field meteorological stations located in agricultural areas equipped with specialized equipment. In the whole system, it is very important to receive real-time local information about occurring meteorological phenomena.

Below a screenshot of the current eDWIN Virtual Farm system is presented, as well a few example mock-ups presenting the pollination scenario.



Karta pola

Nazwa
A2

Numer działki
776

Uprawa
Kukurydza

Odmiana
Odmiana 1

Miejscowość
Dobrzany

Powierzchnia
2 Ha

Rejestr ostatnich zabiegów

Data	Nazwa zabiegu	Środek	Dawka
12.02.09	bronowanie		
17.03.09	orka		
12.04.09		obornikiem	150 kg/Ha

Figure 56: Screenshot of the current eDWIN Virtual Farm system - field view.

Nr pszczelarza: 011234
Ilość uli: 50
Data: 20.04 -27.04. 2020

Nr pszczelarza	Ilość uli	Data	Kontakt
1. 011234	50	20.04 -27.04. 2020	666 - 999 - 777

Figure 57: Mockups of eDWIN system showing pollination offer and pollination agreement details

25.1.2 Used Data

This pilot aims at the optimisation of pollination of arable crops by honeybees. For this reason, the data it will manage cover the following aspects:

- Geospatial data: Location of apiaries, Hives, Fields and spraying events, Local weather data
- Field data: Location, Crop type, seeding date, crop status (e.g. is blooming), field status (is open for pollination), size, field geometry, sprayings, insecticide used, active ingredients
- Apiary and hive data: location, apiary reach, number of hives
- Hive location and conditions (temperature, weight etc.)
- Pollination data: pollination need, saturation, invitations, offers, agreements
- Alerts: Pollination invitations, pollination offers, sprayings, pests, others
- Local weather data: Air temperature, air humidity, wind speed, wind direction, rainfall

Additionally, this pilot manages other general information related to users and companies such as username/pass, personal and contact information. Moreover, use of WP4 DSS services based on satellite imagery for crop type/status identification and image data for pest detection are also considered.

The information exchanged between systems will be modelled taking into account the Agricultural Information Model (AIM) defined in DEMETER. Below we provide an example of the use of the AIM concepts in the pilot context.

```
{
    "@context": [
        "https://w3id.org/demeter/agri-context.jsonld",
    ],
    "@id":"http://w3id.org/demeter/ManagementZone/4",
    "@type": "Plot",
    "landLocation": "Point(52,291677,16.393359)",
    "hasGeometry": "Polygon((-83.6 34.1, -83.6 34.5, -83.2 34.5, -83.2 34.1, -83.6 34.1))",
    "identifier": "1234",
    "area": "35",
    "status": "blooming",
    "hasAgriCrop": { "name": "rape" ,
                     "agroVocConcept": <http://aims.fao.org/aos/agrovoc/c_1066>
                   }
}
```

25.1.3 System Extensions and Applications

In this section we are describing how this pilot is integrated into the DEMETER environment. This is the global view of pilot 5.3 in DEMETER Reference Architecture:

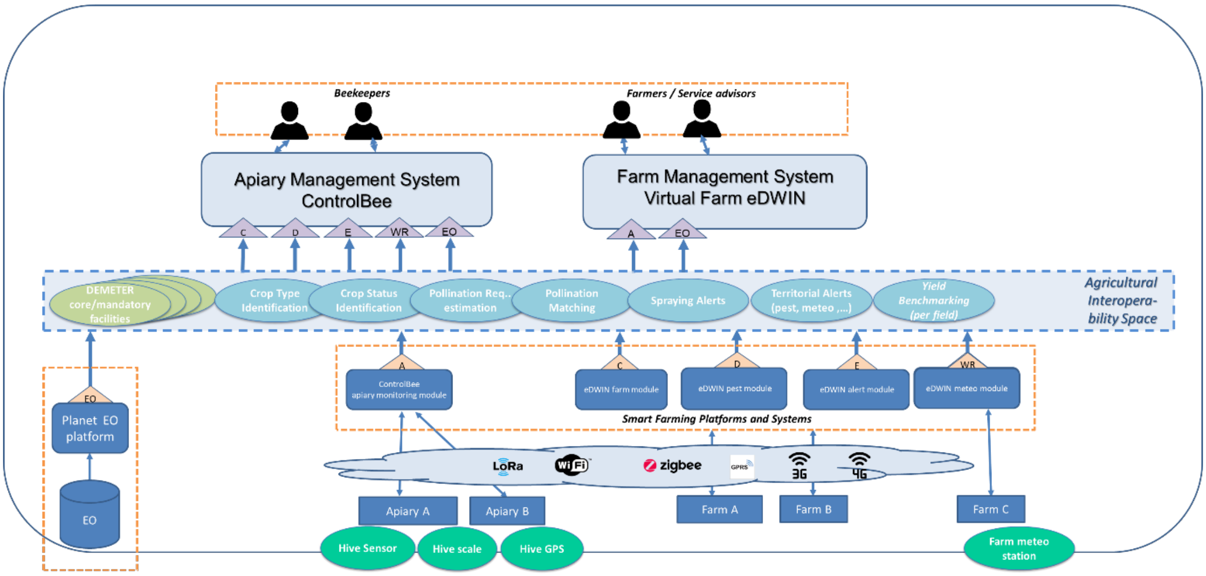


Figure 58: DEMETER Reference Architecture for pilot 5.3

This figure presents the mapping of the DEMETER architecture to the pilot, the delivery of apps through it and the composition of such apps from DEMETER enabled entities, data and services.
The raw resources (e.g. various types of sensors) are presented at the bottom. They are connected through the appropriate communication protocols (LoRa, WiFi, etc.) to existing agrotech systems. In this pilot we can find apiary monitoring and management systems (e.g. ControlBee) and farm management systems (e.g. eDWIN). To make them compatible with DEMETER and to use their data and facilities they will be paired with an appropriate entity (DEMETER Enabler) that will provide an AIM compliant wrapper. The central part of the figure above conforms to the DEH through which all these entities are offered.

Identified pilot-specific or optional DEMETER enablers that are needed for the realization of the pilot scenario, included in the diagrams as the blue oval shapes, are the following:

- Pollination requirement estimation: service calculating how many hives/bees' families are needed to pollinate a field depending on crop type and field size,
- Pollination matching: supporting beekeepers and farmers to get in contact for pollination agreements,
- Spraying alerts: service for notifying beekeepers in neighbourhood when a farmer is applying insecticides to their crops,
- Territorial alerts (e.g. pest, meteo): service for other types of notifications (e.g. pests),
- Crop Type identification: service enabling identification of a crop type on a field or groups of fields, in particular, honey crops (potentially based on data from Farm management system and/or from satellite images - WP4 A.4 component),
- Crop status identification: service for identifying crop status, in particular, start of blooming (based on data from farm management system),
- Yield benchmarking per field (TBC): service enabling farmers to benchmark their field yields with others, to see if bee pollination services bring an increase in yields (to be considered based on WP4 A.1 component).

The blue components compose the functionality of a pollination optimisation service allowing the exchange of data between apiary management systems and farm management systems to support pollination by bees and protect the pollinators. They will be partially implemented in the pilot and partially based on or use DEMETER core/mandatory facilities or use of facilities from other pilots.

Below we can see a diagram presenting a general deployment of the pilot in a DEMETER framework. Pilot comprises of three main group of services:

- ControlBee apiary monitoring system - provides information, access and data exchange about apiaries,
- eDWIN Farm Information and Management system - groups services responsible for information about farms, fields, crops as well as provides modules for serving meteorological data,
- Pollination services - providing functionalities for pollination estimation, pollination matching, spraying and territorial alerts, based on DEMETER decision enablers and advisory support tools developed in WP4 (it is developed in DEMETER project).

Those service groups will be deployed as DEMETER Enhanced Entities within Brokerage Service Environment designated for the pilot. Entities will register their services in the BSE and will be using provided BSE API for service discovery and provisioning. Upon successful authentication and authorization direct connection and data exchange between apiary, pollination and farm services will be established based on REST/Kafka. The diagram below presents a high-level deployment of Pilot 5.3 within DEMETER space.

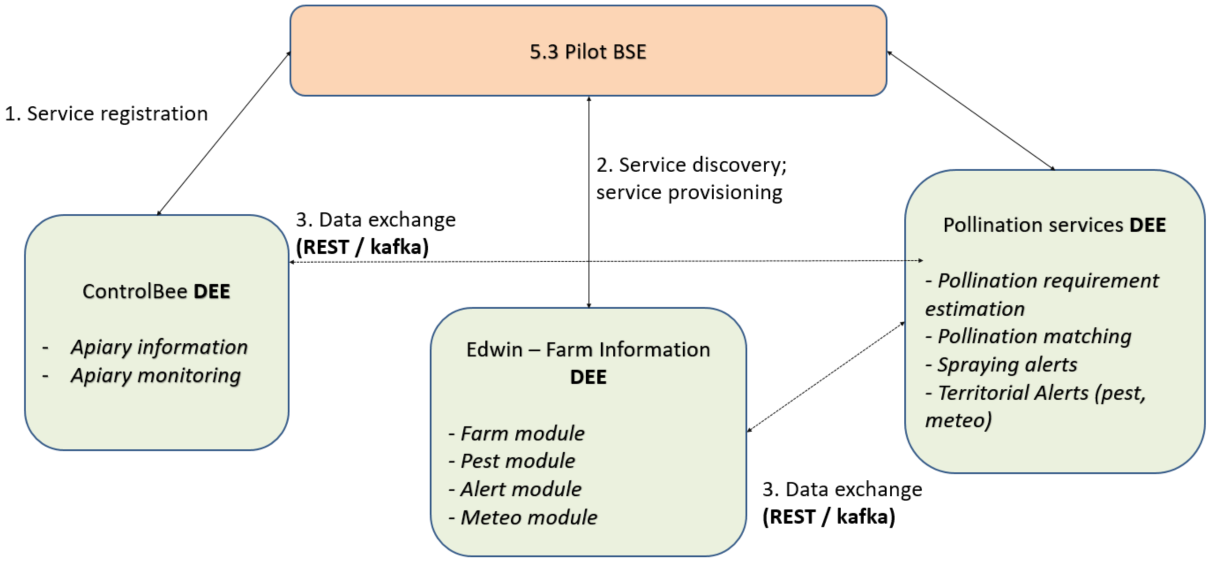


Figure 59: High level deployment of Pilot 5.3 within DEMETER space

26 Pilot 5.4 - Transparent Supply Chain in Poultry Industry

DEMETER needs to transparency in supply chain for poultry industry, providing information about animal wellbeing and resources used during the production, thus creating a basis for a transparent supply chain. It must uniquely identify products on item level and enable data integrity across the value chain as well as prediction of disease, assessment of travel and environmental condition to create instruction for consumers. It must identify and provide algorithms that are able to analyse and process large amounts of data relating to the feeding and stress level monitoring for poultry farms. The detection of elevated stress levels currently exists, so it is a requirement for members of WP4 to use a machine learning algorithm to correlate the onset of raised stress with events detected by other sensors, such as video feeds. This can then be used as part of a complex event processing system to alert the user before the event occurs. The algorithms should also be able to predict the likelihood of particular events occurring. A minimum set of information must be provided, sufficient for the calculation of stress level indicators, power losses (factor that influences stress) in a poultry farm and useful to feed the algorithms as well as for creating instructions for consumers.

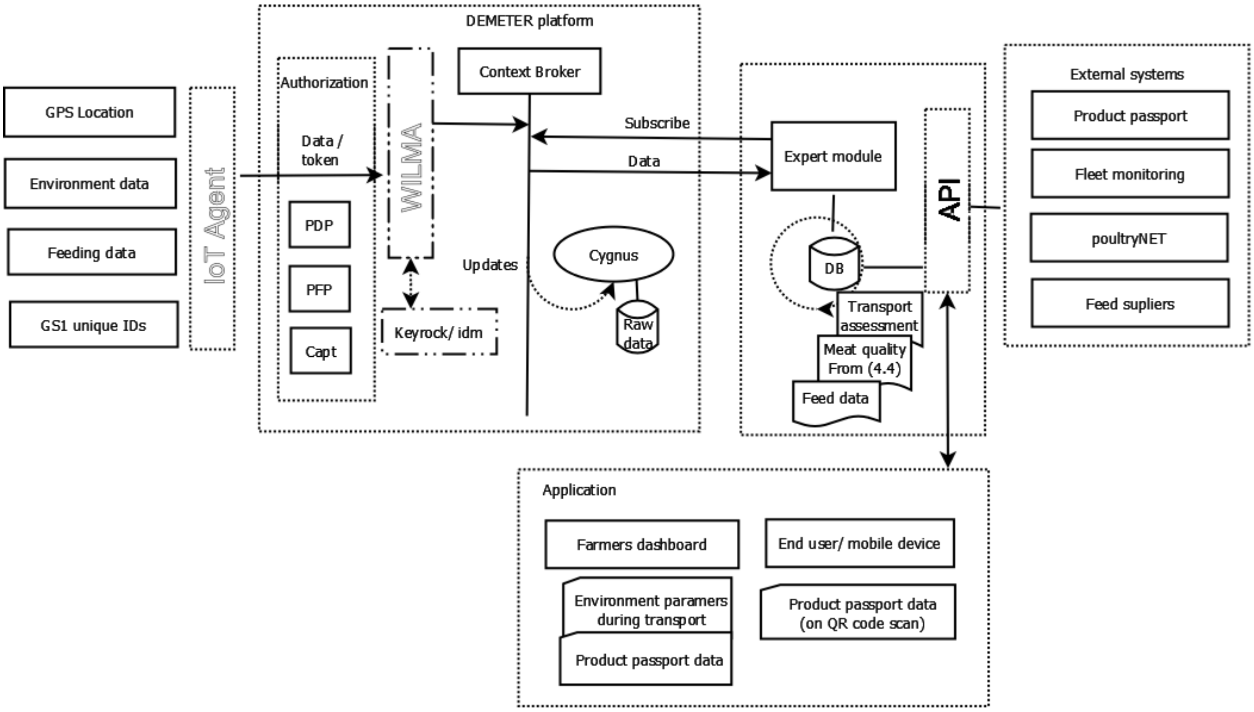
Activities are focusing on collecting data related to on-farm activities (environmental data, animal wellbeing, medical treatment, food and water consumed) and post-farm activities (condition during the transport) providing relevant data to the consumers. Product passport platform will be used for gathering relevant information from different farm management platforms about the supply chain activities (production, transport, retail). A blockchain-based data exchange protocol (OriginTrail) will be used to ensure trust and transparency between actors in the value chain.

The item-level identification will be done using GS1 digital link standard to identify meat packages with the unique identifiers that will allow monitoring of item in different stages from production to consumption. The integrity of the data will be based on Distributed Ledger Technology (DLT): using OriginTrail blockchain protocol. GPS trackers will be used to monitor the travel of the products and provide input for food travel assessment. Environmental condition will be monitored using IoT devices (air speed, CO_2, temperature, humidity.

All information is going to be used to compose product passport for each product putting all relevant data at disposal to the stakeholders: place of production, time of slaughter, environment data, disease model, storage, transport condition, etc.

26.1.1 Use Case Workflow

The following image corresponds to the instantiation of the Reference Architecture defined in DEMETER for pilot 5.4.



Data collected from devices are sent and registered into the DEMETER platform from where they are further recollected to provide service, logic and analytics to different actors using Exert module, interaction with external systems and applications. **Expert module** contains algorithms for quantification of environment during transport, it generated statistics about feed data and reuses meat quality data that will be provided for the product passport with additional relevant information. The final instructions are provided using **dashboard** application and end user mobile application. The components are explained in more details in the next subsection.

26.1.2 Used Data

The pilot will map different data as listed below:

- Product passport: GS1 item-level identifiers, Product information (time, date of production, Animal Stress Data from pilot 4.4), Travel assessment of the product (cold supply chain), Quality of the Environment (from pilot 4.4)
- Poultry Location: GPS location data of the flock provided by GPS sensors connected to the Flock Monitoring System, farm location (latitude, longitude)

It will also use data from registered users:

- Company credentials: Username, Password, Company name

The DEMETER Enablers will ensure the secure exchange of data, the interchange mechanisms and the semantic interoperability by guaranteeing the AIM format. In particular, user credentials (username, password and company name) and geospatial information (poultry GPS location, farm GPS location, product related information) will be directly modelled according to AIM, as defined in D2.1. Information from IoT sensors will be remodelled via AIM-compliant wrappers. Information provided by edge cameras deployed on field, with data about well-being: parameters from sound, power loses, quality of the environment and travel assessment will be processed internally and adapted and integrated into the AIM facilitating adapters for specific ontologies related to livestock features, alerts, properties and systems.

26.1.3 System Extensions and Applications

Pilot 5.4, whose instance of DEMETER reference architecture is shown in Figure 60, presents post farm activities of Pilot 4.4, and it provides product passport updated with data about transport, additional stakeholders' functionalities and data traceability integrated throughout the product lifecycle. The pilot is using capabilities of external systems:

- poultryNET farm system: expert system for detection of environmental parameters on farm with instruction for farmers
- Silo monitoring service: detection of amount of food in silo using radar sensor (data from pilot 4.4)
- Farm ERP: Internal farmers system (not available on all farms) (data from pilot 4.4)
- Chicken feed suppliers: data from the use case will be offered to chicken feed suppliers to enable more intelligence in the overall supply chain and especially to the feed suppliers.

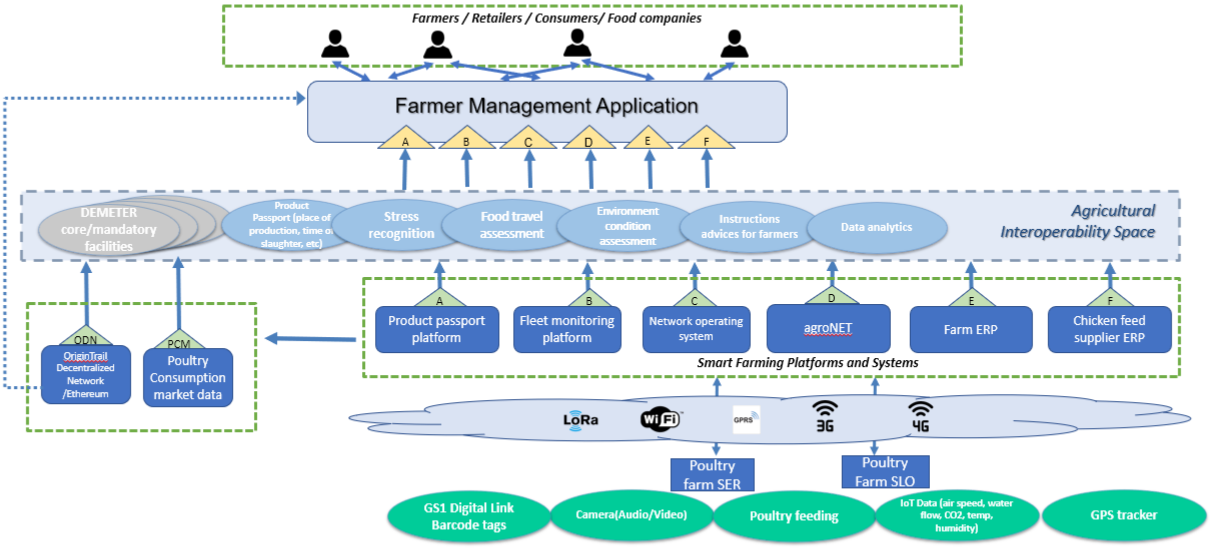


Figure 60: DEMETER Reference architecture for Pilot 5.4

To make them compatible with Demeter and to use their data and facilities they are paired with an appropriate entity (Demeter Enabler) that will provide an AIM compliant wrapper. The central part of Figure 60 conforms the DEH through which all these entities are offered. On the left, we find Demeter mandatory entities (grey) to be used by the optional ones (blue) needed by this pilot represents subcomponents of the Expert module:

- Product passport: Component that provides all relevant product information (place of production, time of production, poultry health, etc). Poultry well-being (health) is assessed in pilot 4.4 using different services: Power loses: component detect power loses to indicate this parameter for the chicken stress; Silo condition detection: This component detects amount of food in the silo using the radar senor
- Food travel assessment: This component assesses pre and post farm activities using feed, transport conditions (when transporting 1-day chicken), as well as the cold chain assessment
- Instructions and advices for consumption: instruction added directly fitting to the required models used for assessment based on input parameters

These enablers offered by the DEH are used to compose the Demeter Enabled Applications for the business solutions of the pilot that are presented at the top of the figure with the application that provides decision support system in form of instructions for farmers.

27 DEMETER components adopted in the first pilot round

Technical WPs and WP5 work closely together: data collected from the pilots as well pilot requirements, envisioned scenarios, RA instances and visualization needs represent inputs that technical WPs (WP2, WP3 and WP4) have to take into account in the definition of their specific technical requirements. Likewise, DEMETER offers a set of core enablers needed for creating any DEMETER applications and so mandatory for any interested stakeholder who wishes to expose or share his/her own resources and also offers advanced enablers that are optional, discoverable and accessible through the Hub by pilots with specific/generic needs.

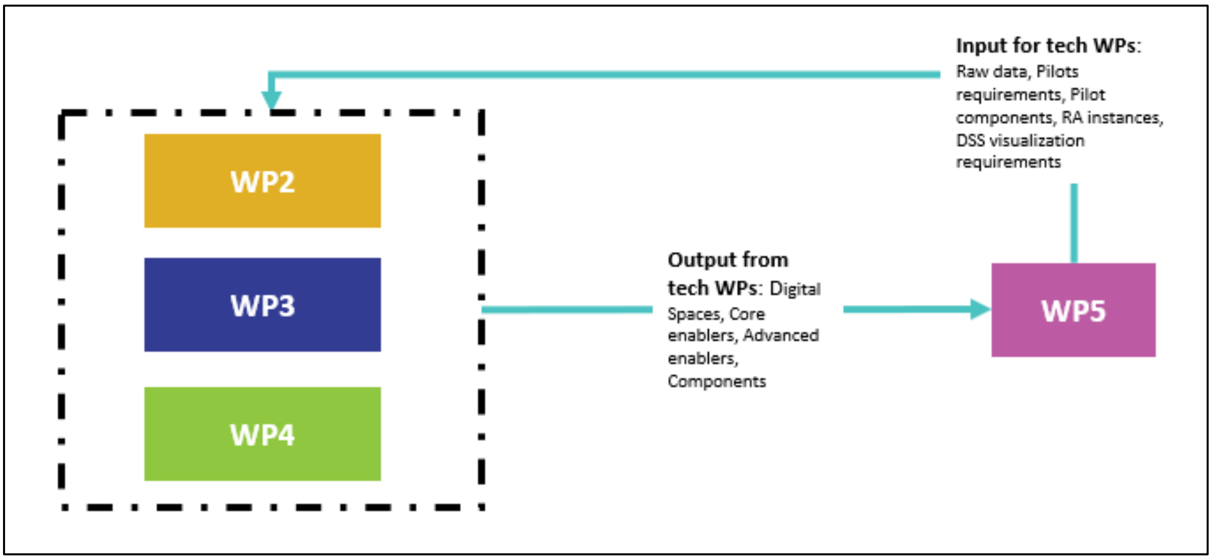


Figure 61 Technical WPs and WP5 input-output relations

Since D5.3 aims to capture the results of the setup and system deployment at pilot sites as well all the systems extensions and applications to be used for pilots round 1, it is considered of interest to include a sort of summary about the components developed within DEMETER and their usage by pilots at the eve of the first pilot round.

The scope is indeed that DEMETER pilots use, validate, experiment and providing feedback on as many as possible DEMETER components in order to better address interoperability challenges brought by DEMETER farmers. The usage by pilots of the DEMETER components will be facilitated by means of technical WP sessions on the results obtained and collected within the technical deliverables (D2.1, D2.2, D3.2, D4.2).

Here they follow some brief descriptions about areas and components, realized within technical WPs, and grouped by task (WP2 and WP3) or identified area (WP4). These descriptions aim to highlight the reasons why some components are mandatory as well give some insights on advanced enablers and other components. However, this is just one of the efforts through which technical WPs will spread their results, indeed they will organize sessions for pilots having the scope to share more information about the components, in order to have as many pilots as possible using and validating them.

27.1 WP2 components adoption

In this section a high-level description of the functionality of the WP2 modules is provided. More specifically, the enablers related to data and knowledge that are provided by WP2 fall under four areas matching with WP2 tasks: *AIM model and semantic interoperability support* (area A); *data management and integration* (area B); *data quality, fusion and analytics* (area C); and *data security and privacy* (area D).

The first area of WP2 enablers (area A) involves the AIM and the semantic interoperability that is supported via the established mappings from/to AIM to/from well-known existing ontologies and respective standards. In more detail, the elements and functionality of these two enablers are presented below.

Agriculture Information Model (AIM) [2.A.1]: this core enabler represents the DEMETER AIM data model that is used across DEMETER and is the basis of the common “language” used for data sharing. It is comprised of four subcomponents:

a) the ***Core Meta-Model*** that is based on the NGSI-LD meta-modeling approach. It specifies the cross-domain ontology Semantic modelling language (OWL used for domain models, as classes and properties), the Terminology definition language (SKOS used for concept labels and their definitions, the Structural schema/frame (SHACL and RDF-Datacube are used to model, e.g. the data shapes), and finally how to bind these elements together (using appropriate profiles).

b) the ***Cross-domain ontology*** that defines several cross-domain concepts, namely, geographical and geometrical properties, temporal properties and time values, and units of measurement, general models for sensors and actuators (e.g. using concepts for SOSA/SSN), as well as Earth Observation data.

c) the ***Domain-Specific ontologies*** that will cover the data needed to be stored in each individual agri-domain. These include the following ontologies: agri-profile, agri-commons, agri-features, agri-crops, agri- interventions, agri-alerts, agri-product, agri-properties, agri-systems, agri-pests, as well as the farm animals’ ontology. These deal with specific domains, such as crops, plots of land, operations on farms or animals.

d) the ***Metadata Schema*** that describes the meta-information that is maintained about the rest of the AIM data, ranging from basic info such as their ownership and origin, their type and description, up to more specialised information such as declarations of conformance. For implementing this, ontologies such as Data Catalog Vocabulary (DCAT) have been reused.

Semantic Interoperability Support [2.A.2]: this core enabler facilitates the translation of external data (perhaps from existing sensors or FMIS) to and from AIM in order to enable the semantic interoperability of DEMETER data with existing systems that use other (standard) data models and ontologies. To this end, AIM imports concepts from a number of well-known ontologies, such as FIWARE, Saref (and Saref4Agri), ADAPT, Inspire (and FOODIE), AgroVoc, Earth Observation standards, etc., and establishes the necessary mappings among the equivalent concepts across these ontologies. These mappings support the straight-forward development of translators between AIM and foreign ontologies. To facilitate this process, the semantic interoperability support will offer specific mechanisms such as discovery of AIM terms, extraction of established AIM mappings and validation of compliance of given instances with AIM to developers.

For more information on the previous two sets of enablers and tools please refer to deliverable D2.1 Common Data Models and Semantic Interoperability Mechanisms - Release 1.

Building upon this model, the second area of WP2 enablers (area B) deals with the management preparation and integration of the data collected in DEMETER. It includes the following two enablers.

Data Management [2.B.1]: this advanced enabler allows consistent access and delivery of data to meet the data consumption requirements of all applications, as well as possible storage of such data for later use and analysis. It ensures uniformity, accuracy, management, governance, semantic consistency for the data used by a DEMETER application.

Data Preparation & Integration [2.B.2]: this advanced enabler allows the cleaning and transformation of raw data prior to them being processed and analysed. It often involves reformatting data and standardizing data formats, making corrections to data, removing outliers and combining data sets to enrich data. It allows fixing errors, so the data used will be of high quality and will allow making better decisions.

Having obtained the data in the correct format (compatible with AIM) and then ensuring their proper management and integration into the application, the third area of WP2 enablers (area C) deals with extracting knowledge from the data. This breaks down into first ensuring the quality of the incoming data and then the subsequent fusion of such data as well as the use of data analytics to extract knowledge from them. It is made up of the following four enablers.

Data Quality [2.C.1]: This advanced enabler checks if incoming data meets general quality criteria and if use case specific requirements such as plausible data ranges and distributions are respected; this data can then be fed into fusion, analytics and decision support tools.

Targeted Data Fusion [2.C.2]: This advanced enabler fused together data from various sources (e.g. multiple sensors) extracting useful features and values from this process. There are two sources of complexity that this enabler addresses: a) very heterogeneous data coming from a wide variety of components and sensors, which might however capture similar aspects of the real world, and b) data generated by groups of sensor often has redundancy, impreciseness, uncertainty, outliers and quality issues, e.g. due to noise, or due to sensors being down for some amount of time. This heterogeneous, noisy, redundant data is fused together into a few key features which are then transmitted to the analytics and decision support tools.

Targeted Data Analytics [2.C.3]: This advanced enabler extracts knowledge from cleaned data using a number of techniques most notably machine learning algorithms targeted to extracting knowledge in specific domains. These algorithms are customized to the specific tasks required by the pilots. For example, DEMETER offers diverse tools such as for counting fruit flies, or for estimating the optimal use of fertilizer, or for analysing water salinity and plant toxicity using appropriately tailed computer vision and neural network algorithms.

Machine Learning Analytics [2.C.4]: This advanced enabler aims to generalise and extend the tasks performed by the targeted data analytics. It deals with the labelling of training data and the acquisition of the labels for these; with automating the selection of generic (as opposed to targeted specific) algorithms for specific problems; with being able to explain the knowledge derived from analytics and how it is generated; and finally, storing the derived models for each application and facilitating the integration with decision support tools that use this derived knowledge.

The final set of WP2 core enablers fall under area D and deal with **Data Security & Privacy** [2.D]. These enablers consider the access to the data at different levels ranging from access to the system, authentication, access to the resources, authorization, as well as access to the data, privacy or confidentiality.

Authentication enabler [2.D.1]: this enabler authenticates each user (using a password-based login).

Authorisation enabler [2.D.2]: this enabler takes the credentials from the authentication and using a decentralized approach authorised each user for the applications and data that he should be given access to and how much control she should have over various components of the system using the appropriate authorisation/capability tokens.

Traceability enabler [2.D.3]: this enabler essentially provides logger services (using blockchain technologies) for actions taken by users as authenticated and authorised by the previous two enablers, such as information about the users logged in the system and the resources users access.

Confidentiality enabler [2.D.4]: this enabler handles the required data protection in order to protect and enable user data privacy issues, e.g. ensuring the prevention of data access by unauthorized users.

For more information on data management, quality, fusion and analytics and security enablers and tools please refer to deliverable D2.2 Data and Knowledge extraction tools - Release 1.

In WP2 pilot mapping table, in Annex 5, you can find a mapping table showing the WP2 components selected by pilots for this first round (the X indicate either the components that were selected by the pilots or the mandatory ones as core enablers; the (X) can indicate that either it is not certain that the pilot will be using these components in pilot round 1 or these will be used indirectly via the data analytics modules).

27.2 WP3 components adoption

Under WP3, there are components that are being developed and are considered mandatory for any pilot that would like to use DEMETER capabilities. These components are necessary because they provide functionality that DEMETER Enhanced Entities utilize to interoperate. WP3 components were grouped in three areas taking as reference the following WP3 tasks: Task 3.2 Technical Interoperability and Service Provisioning (Area B), Task 3.4 Connectivity and Security Framework (Area D), Task 3.5 DEMETER Hub (Area E). Below, the components that are currently included in WP3 (further details available in D3.2, M10).

The first area of WP3 components (area B) involves:

1. **Brokerage Service Environment** [3.B.1]: The BSE is a core component of DEMETER architecture, which facilitates the registration, discovery and ultimately communication process for the DEMETER-enabled resources in a secure and privacy preserving manner.
2. **Functional Interoperability** Enabler [3.B.2]: Functional Interoperability Core Enabler is the client-side of the Brokerage Service Environment. This Enabler provides all the services of the BSE to the rest of the Enablers (Core and Advanced) and to the Consumer's application. It serves as a wrapper for the Registration, Discovery, and Provisioning services offered by the BSE.

The second area of WP3 components (area D) involves:

3. **Access Control Server** [3.D.1]: this includes security components that provide the Authentication, Authorization, and Traceability functionalities to other DEMETER components and pilots implementations.
4. **Security Enabler** [3.D.2]: The Security Authentication Enabler library provides to the DEMETER components and the pilots developers an abstract way to access to the Authentication OAuth 2.0 functionalities exposed by the DEMETER Authentication component REST API.
5. **Communication & Networking Enabler** [3.D.3]: this module provides confidentiality properties to a client-server communication, to prevent unauthorized readings or alterations by malicious users.

The third area of WP3 components (area E) involves:

6. **DEMETER Enabler HUB** [3.E.1]: the DEMETER Enabler HUB (DEH) is one of the most crucial components of the DEMETER project; it represents the digital space dedicated to end users of DEMETER where they will be able to create and register their own resources.
7. **DEH Client Enabler** [3.E.2]: some of the resources and data that will be exposed and used by the DEH Dashboard will be hosted by third parties or on remote or private infrastructures. The role of the DEH Client Enabler is to provide some libraries, SDKs or tools that can make exposing these resources as easy as possible for the providers.

A specific table for mapping pilots with WP3 components is presented in Annex 5.

27.3 WP4 components adoption

Regarding the DSS to be developed under WP4, it is compound of several modules (DSS-areas) that will suit farms and farmer's needs. Each of the areas is compound by a series of components offering their functionalities to cover certain aspects as requested by the DEMETER Pilots. Below, the areas that are currently included in WP4 (further details about their components is available in Deliverable 4.2):

Crop Farming:

1. DSS AREA: A - Crop Growth, Status and Yield. This area covers the decisions related to the assessment of plant condition, crop stage and harvesting. It is composed of 5 components.
2. DSS AREA: B - Irrigation Management. This area deals with water management and irrigation, estimating the water requirements and defining the optimal scheduling of the irrigation. It is composed of 2 components.
3. DSS AREA: C - Nutrition Management. All decisions related to the fertilisation and the management of crop nutrition issues are dealt inside this area. Like Area B, it is composed of 2 components.
4. DSS AREA: D - Machinery and Field Operations. Tillage operations, machinery management and the analysis of machine-related data are the activities covered by this area. It is composed of 3 components.
5. DSS AREA: E - Pest and Disease Management. In a farm, the decisions related to control the actions to reduce the impact of pest and disease on the production are of paramount importance. These are the activities covered by the 2 components of this area.

Livestock Farming:

6. DSS AREA: F - Animal Yield. All decisions related to animal feeding, husbandry and the analysis and prediction of both product quantity and quality are dealt inside this area. Like many of the previous areas, it is also composed by 2 components.
7. DSS AREA: G - Animal Welfare. Any kind of decision related to the monitoring and the improvement of animal welfare could be taken with the information provided by this area’s 2 components.

Farm General Management:

8. DSS AREA: H - Traceability. This area involves the decisions related to marketing, food traceability along the food chain and the official documentation needed to be managed. It is composed by 3 components.
9. DSS AREA: I - Benchmarking. Monitoring and comparison within the same farm or with the neighbour’s farms are expected to monitor economic, agronomic and environmental performances even to choose the right technologies to improve performance of the involved farms. This area is composed by 4 components.

Finally, in WP4 pilot mapping table, Annex 5, you will find the mapping table showing the WP4 components selected by pilots for this first pilot round (the X indicate the pilot makes use of the components, the T indicate the pilot might make use of the component).

28 Conclusions and Next Steps

Along different sections, this document describes the procedure to deploy the DEMETER’s pilots focussed in the first of the two rounds of the deployment. Every pilot has described its objectives and KPIs with achieved goals, its use case workflow, its used data, its system extensions and applications and its implementation plan. Pilots also describes the needed adaptations required for them to be integrated in DEMETER though their interaction with the DEMETER Enabler Hub and the Brokerage Service Environment components.

This document is based on work done in task 5.2 “Pilot testbed management, pilot applications, system extensions and deployment at pilot sites” and utilizes work done in WP3 (D3.2 “DEMETER Technology Integration Tools”).

For the next iteration of this deliverable an in-depth review of the pilots will take place in collaboration with the other work packages. Key objectives are:

- Testing of pilots.
- Revision of pilots’ requirements with stakeholders.
- Interoperability and security arrangements.
- Integration of data produced on farms with externally provided data from the platform.
- Analysis, knowledge extraction and visualization of acquired data from pilots.
- Development and integration of a Decision Support System (DSS).
- Mapping of pilot’s data with the AIM

Annex 1 – Detailed list of KPIs achieved up to data

Objectives 1&2

List of DEMETER interoperability mechanisms implemented (12/>=50)

- AfarCloud Middleware,
- Data Brokerage Service for DSS,
- Data Brokerage Service, for Farm management,
- ETSI NGSI-LD,
- Farm Proxy,
- FIWARE NGSIv2,
- GeoJSON,
- JSON,
- JSON-LD (AIM)
- Kafka message broker,
- MEGA,
- REST

List of solutions present in DEMETER (34/>=100)

- Animal Welfare DSS, App for product quality and user feedback,
- App for production management in livestock farm;
- Automated job identification & documentation,
- Benchmarking; Computer vision-based counting;
- ControlBee;
- Crop growth & status & yield,
- Eana Ku;
- eDWIN,
- eDWIN eODR;
- Farmers' collaboration platform,
- Fertilisation management,
- FertiRM;
- HSlayersNG,
- Irrigation management,
- Input management;
- Job cost calculation for spraying & fertilization,
- Layman;
- MEGA Coordinator,
- OLIWES (3);
- (Open)Micka,
- Offering-demand sharing platform,
- SensLog,
- SIS-Rice,
- SIS-Maize,
- Smart Agriculture;
- Traceability DSS,
- WatchItGrow (3);
- WP2 component "data quality assessment"

List of different suppliers involved in DEMETER (77/>=60)

- AGRICOLUS,
- APPR,
- ATOS,
- AVINET,
- AVR,
- Centria,
- Codan,
- DNET,
- ELGO,
- ENG,
- Frackowiak,
- ICCS,
- IDEATRONIK,
- IERiGZ,
- Landbrukets Dataflyt,
- Mimiro,
- Napierala,
- OdinS,
- Probot,
- PSNC,
- ROT,
- SIMAVI,
- Tecnalia,
- TRAGSA,
- UMU,
- UPM,
- Vantage,
- VICOMTECH,
- VITO,
- WODR,
- Vineyards (14);
- Transport &
- Retailers &
- Consumers (15+15)

List of external components / data hubs connected to DEMETER (5/>=27)

- AFarCloud Middleware,
- Afilab (milk quality), Aficollar (rumination heating habits),
- Agro-market information,
- Copernicus ERA5,
- Copernicus Sentinel 2,
- ControlBee,
- DAVIS weather stations,
- Datalog (animal temperature),
- eDWIN,
- Eurostat,
- FADN EU,

- FADN PL,
- Landsat7,
- MilkoBox (real-time milk analysis), MilkoScan (milk traceability & off-line milk analysis),
- NCDX,
- OGC SOS,
- OGC visualization,
- OpenFoodfacts, Pedometer,
- PESSL weather stations,
- Proba-V,
- Romanian meteorological system,
- Smart Agriculture,
- WatchItGrow

List of new deployments at farmers (see pilots and open calls) (131/>= 30)

- (6) in Spain
- (15) in Romania,
- (5) in Germany
- (2) in Czech Republic,
- (9) in Poland,
- in Latvia,
- (10) in France,
- (5) in Greece,
- (+33) in Italy,
- (20) in Belgium,
- in Finland
- (24) Others

List of harmonization's and contributions to standards (12/>=10)

- AIM,
- CAP,
- ETSI NGSI-LD,
- Eurostat,
- FADN,
- FIWARE NGSIv2,
- GS1,
- ICAR ISO21622 (MEGA),
- OGC SOS,
- OGC visualization,
- openEO

Objective 3

List of data sharing agreements (96/>=500)

- Irrigation Communities: 2;
- Agreements with APPR: 15;
- Farms: 28;
- Poultry farms: 20;

- Dairy farms: 5;
- Vineyards: 14;
- Beekeepers: 4;
- Maccarese: 1,
- Latte Sano: 1;
- Others: 6;

Objective 4

Comparison / selection of solutions during DEMETER's lifetime (44/>=30)

- 4 identified and named solutions, as well as other 40 estimated thanks to the collaboration of the pilots.
    - MEGA Coordinator;
    - OLIWES Fertilisation DSS
    - OLIWES Water management DSS,
    - Smart Agriculture platform

Number of tools and datasets tried in pilots (>5000/>=5000)

- AfiCollar,
- Afilab sw,
- Agro-market data,
- Data Log,
- Economic data,
- Eurostat,
- eDWIN,
- FADN PL,
- FADN EU,
- IoT devices,
- IoT gateways (AFarCloud, Middleware,Farm Proxy),
- Milk data (Milking robot, Milk Box MKII, MilkoScan FTIR),
- NCDX,
- NOx,
- Pedometer,
- Production data,
- Satellite imagery (agro-indexes, cartography),
- Soil,
- Traceability of poultry,
- Weather/ambient

So far, we have identified and named a total of 28 tools and 130 datasets.

Objective 5

List of suppliers teaming up to address needs expressed by farmers (16/>=30)

- AGRICOLUS, APPR & Vantage;
- AVINET,

- DNET,
- ENG & ROT;
- Fraunhofer IESE;
- John Deere,
- m2Xpert,
- PSNC;
- SIMAVI & APPR,
- VICOMTECH,
- VITO;
- VITO & AVR,
- VITO & ELGO,
- VITO & AGRICOLUS;
- WODR

List of farms addressed (>1600/>=50000)

- Olive farms: 8,
- Dairy: 570,
- Norwegian farms: 1000,
- Maccarese: 1,
- Other Farms: 64

Objective 6

List of suppliers of solutions sign up to DEMETER (11/100)

- AVINET,
- Centria,
- Codan,
- OdinS,
- Probot,
- PSNC,
- Tecnalia,
- TRAGSA,
- UMU,
- UPM,
- WODR

List of pilots deployed across different sectors (6/5)

- P1.1&1.2: Arable crops;
- P2.1: Arable crops;
- P2.3: Arable farm
- P5.1: Farmers,
- retailers, consumers,
- agriculture machinery-robotics vendor;
- P5.2: Animal wellness, production improvement and food traceability;
- P5.4: Farmers, retailers, consumers, agriculture machinery-robotics vendor;

Annex 2 - Contribution to objectives and KPIs per pilot

Pilot 1.1&1.2 Water Savings and Smart Energy Management in Irrigated Crops& Arable Crops

Pilot 1.1&1.2 contributes to the general objectives: *O1, O2, O3, O4, O6*.

Table 3: Pilot 1.1&1.2 contribution to general objectives and KPIs

Objective #1 – Information Modelling & Objective #2 – Knowledge Exchange Mechanisms	
Agriculture Interoperability Space deployed	DEMETER Interoperability mechanisms: MEGA, ETSI NGSI-LD and FIWARE NGSIv2.
	Solutions presented in DEMETER: MEGA Coordinator and Smart Agriculture.
	Number suppliers involved in DEMETER: TRAGSA, OdinS and UMU.
	Number of external components: 2 (ISO21622 Communication Broker and Smart Agriculture Broker).
	New deployments at farmers: 2 (Irrigation Community in Castilla & León Region and in Murcia Region)
	Number of harmonization's and contributions to standards: ETSI NGSI-LD, FIWARE NGSIv2 and ISO21622 (MEGA)
	Volume of data observing: Only considering the 2.382 hydrants, with a 5-minute data stored for each one, we can get 28.584 data by hour. In addition to this information we must count with historical information of satellite images for each of the locations, as well as the corresponding indices that they generate.

Objective #3 – Data Ownership	
Farm context model including inventory of data sources.	The information obtained from farms represented in NGSI or MEGA thanks to Smart Agriculture platform and MEGA Coordinator.
New business models defined and adopted	Although it is still too early, in this stage of the project to define new business models, the interoperability capability provided by DEMETER will open new solutions based on the exchange of information of platforms and IoT gateways manufactured by different vendors.
Data exchange mechanisms implemented within DEMETER	Number of data exchanges (with financial retribution of farmers) >= 50 NGSI, NGSI-LD and MEGA which defines both data models and API which has been identified as interoperability technologies to be integrated into the DEMETER AIM.
Exposure of farmer sourced data through DEMETER	Number of data sharing agreements: 2 (Irrigation Community "Left side of Porma River" and "Comunidad de Regantes Campo de Cartagena").

Objective #4 – Benchmarking	
Proposed benchmarking mechanism elaborated with	Comparison / selection of solutions during DEMETER's lifetime: 2 (Smart Agriculture from OdinS and MEGA technology from Tragsa).

participation of over 500 farmers	Water and pesticide usage per yield unit and per hectare: Not defined yet.
	Number of tools and datasets tried in pilots: Regarding the Irrigation Community of Campo de Cartagena, they will provide datasets corresponding to IoT Gateways providing soil information, meteorological stations equipped with the corresponding ambient sensors. Additionally, the different datasets of indices (NDVI, NDWI, …) featured by satellite images are going to be integrated too.

Objective #6 – Real World Impact	
Fully deployed DEMETER ecosystem	100 service advisors sign up to DEMETER: Not determined yet
	100 suppliers of solutions sign up to DEMETER: TRAGSA, OdinS and UMU.
	Pilots deployed across 5 different sectors: Arable crops in two different locations of Spain.

Pilot 1.3 Smart Irrigation Service in Rice & Maize Cultivation

Pilot 1.3 contributes to the general objectives: *O1, O2, O3*.

Table 4: Pilot 1.3 contribution to general objectives and KPIs

Objective #1 – Information Modelling & Objective #2 – Knowledge Exchange Mechanisms	
Agriculture Interoperability Space deployed	DEMETER interoperability mechanisms implemented: NGSI-LD
	Number of solutions present in DEMETER: 1) Smart Irrigation Service for Rice (SIS-Rice) 2) Smart Irrigation Service for Maize (SIS-Maize) 3) Fertilisation Advisory Service for Rice & Maize (FertiRM)
	Number of different suppliers involved in DEMETER: ELGO and ICCS.
	Number of external components / data hubs connected to DEMETER: Not determined yet in this first round
	New deployments at farmers: One Group of Farmers in the Kalochori area near Thessaloniki, Greece.
	Number of harmonization's and contributions to standards: Not determined yet
	Volume of data observing the information models: From the three IoT nodes, we get measurements every hour (date/time, water height, and electrical conductivity), so we collect 72 data records per day (for approximately 3 months). For the other services we also collect UAV and satellite multispectral imagery at multiple time points, as well as the corresponding spectral indices that we generate from them.

Pilot 1.4 IoT Corn Management & Decision Support Platform

Pilot 1.4 contributes to the general objectives: *O2, O3, O5*.

Table 5: Pilot 1.4 contribution to general objectives and KPIs

Objective #1 – Information Modelling & Objective #2 – Knowledge Exchange Mechanisms	
Agriculture Interoperability Space deployed	DEMETER interoperability mechanisms implemented: FIWARE NGSIv2
	Number of solutions present in DEMETER: • Crop Growth, Status and Yield – Plant stress detection (Warnings and recommendations such as: Forecast and Pest Alert) • Fertilisation Management – Nutrient management, Nitrogen balance model • Irrigation Management • Input Management (Plans for differentiated distribution of variable rate inputs such as: Fertilisation plans, Sowing plans)
	Number of different suppliers involved in DEMETER: SIMAVI, APPR and Vantage
	Number of external components / data hubs connected to DEMETER: Landsat7, Copernicus Sentinel 2, Proba-V, Romanian meteorological system
	New deployments at farmers: 15 pilot partner farms in Romania.
	Number of harmonization's and contributions to standards: Not determined yet
	Volume of data observing the information models: • Sentinel-2 and Copernicus data for the selected fields (~1GB for relevant fields /month) • Weather station in selected farms 1 query x 15 farms / hour (~100MB/month) • Meteorological data over Romania (~30GB/month) • In-situ data (~100MB/month)

Objective #3 – Data Ownership	
Farm context model including inventory of data sources.	Yes
New business models defined and adopted	Pilot 1.4 will support the creation of new business models in the future.
Data exchange mechanisms implemented within DEMETER	Number of data exchanges: Not yet decided
Exposure of farmer sourced data through DEMETER	Number of data sharing agreements: 15 data sharing agreements signed with APPR

Objective #5 – User Oriented Solutions	
Running ‘challenges’ based on farmer needs.	Groups of suppliers teaming up to address needs expressed by farmers: SIMAVI and APPR, APPR and Vantage
Open co-creation space for suppliers to team up and answer farmer needs.	Number of farms addressed: 15

Pilot 2.1 In-Service Condition Monitoring of Agricultural Machinery

Pilot 2.1 contributes to the general objectives: *O1*, *O4*, *O5*, *O6*.

Table 6: Pilot 2.1 contribution to general objectives and KPIs

Objective #1 – Information Modelling & Objective #2 – Knowledge Exchange Mechanisms	
Agriculture Interoperability Space deployed	DEMETER interoperability mechanisms implemented: Not determined yet
	Number of solutions present in DEMETER: Not determined yet
	Number of suppliers involved in DEMETER: Not determined yet
	Number of external components: Not determined yet
	New deployments at farmers: 2 (One Logger at Technologie- und Förderzentrum / Versuchsstation Grub (LFL), second one will soon be deployed at Hofgut Neumühle, Germany).
	Number of harmonization’s and contributions to standards: Not determined yet
	Volume of data observing the information models: Logging CAN data of 2 tractors with about 1.5GB per day

Objective #4 – Benchmarking	
Proposed benchmarking mechanism elaborated with participation of over 500 farmers	Comparison / selection of solutions during DEMETER’s lifetime: Not determined yet
	Water and pesticide usage per yield unit and per hectare >= decrease on 15%: N/A
	Number of tools and datasets tried in pilots: First dataset of NOx data was gathered in idle. In service data sets will follow and will be compared to regulations

Objective #5 – User Oriented Solutions	
Running ‘challenges’ based on farmer needs.	Groups of suppliers teaming up to address needs expressed by farmers: Not determined yet
Open co-creation space for suppliers to team up and answer farmer needs.	Number of farms addressed: Not determined yet

Objective #6 – Real World Impact

Fully deployed DEMETER ecosystem	100 service advisors sign up to DEMETER: Not determined yet
	100 suppliers of solutions sign up to DEMETER: Not determined yet
	Pilots deployed across 5 different sectors: One farm in Bavaria and one in Rhineland-Palatinate.

Pilot 2.2 Automated Documentation of Arable Crop Farming Processes

Pilot 2.2 contributes to the general objectives: *O1, O2, O3, O5, O6*.

Table 7: Pilot 2.2 contribution to general objectives and KPIs

Objective #1 – Information Modelling & Objective #2 – Knowledge Exchange Mechanisms	
Agriculture Interoperability Space deployed	DEMETER interoperability mechanisms implemented: 2 (Automated job identification and documentation, job cost calculation for spraying and fertilization application)
	Number of solutions present in DEMETER 3 (Automated job identification and documentation, job cost calculation for spraying and fertilization application, and use of the WP2 component “data quality assessment” adjusted to the pilot’s needs)
	Number of different suppliers involved in DEMETER: John Deere, m2Xpert, Fraunhofer IESE
	Number of external components / data hubs connected to DEMETER: John Deere, m2Xpert
	New deployments at farmers: 3 farms in Germany
	Number of harmonization’s and contributions to standards: Potentially to OGC SOS, OGC visualization standards
	Volume of data observing the information models: About 50Mb per working day (i.e., by spraying and fertilizing applications)

Objective #3 – Data Ownership	
Farm context model including inventory of data sources.	N/A
New business models defined and adopted	N/A
Data exchange mechanisms implemented within DEMETER	Number of data exchanges: N/A
Exposure of farmer sourced data through DEMETER	Number of data sharing agreements: 3 Farms

Objective #5 – User Oriented Solutions	
Running ‘challenges’ based on farmer needs.	Groups of suppliers teaming up to address needs expressed by farmers: John Deere, m2Xpert, Fraunhofer IESE

Open co-creation space for suppliers to team up and answer farmer needs.	Number of farms addressed: 3 Farms

Objective #6 – Real World Impact	
Fully deployed DEMETER ecosystem	100 service advisors sign up to DEMETER: 3 service advisors
	100 suppliers of solutions sign up to DEMETER: Not determined yet
	Pilots deployed across 5 different sectors: Not determined yet

Pilot 2.3 Data Brokerage Service and Decision Support System for Farm Management

Pilot 2.3 contributes to the general objectives: *O1, O2, O3, O6*.

Table 8: Pilot 2.3 contribution to general objectives and KPIs

Objective #1 – Information Modelling & Objective #2 – Knowledge Exchange Mechanisms	
Agriculture Interoperability Space deployed	DEMETER interoperability mechanisms implemented: Data Brokerage Service for Decision Support System and for Farm Management.
	Number of solutions present in DEMETER: 4 solutions in DEMETER: SensLog, HSlayersNG, (Open)Micka and Layman
	Number of different suppliers involved in DEMETER: WODR, AVINET, PSNC
	Number of external components / data hubs connected to DEMETER: OGC SOS, OGC visualization standards
	New deployments at farmers: 6 farms in the following countries: CZ – 2 sites, PL– 2 sites, LV – 1 site, NO – 1 site
	Number of harmonization’s and contributions to standards: Potentially to OGC SOS, OGC visualization standards
	Volume of data observing the information models: Not determined yet

Objective #3 – Data Ownership	
Farm context model including inventory of data sources.	Available: Yes
New business models defined and adopted	Available: Pilot 2.3 will support the creation of new business models.
Data exchange mechanisms implemented within DEMETER	Number of data exchanges: N/A
Exposure of farmer sourced data through DEMETER	Number of data sharing agreements: 6 agreements with farmers

Objective #4 – Benchmarking	
	Comparison / selection of solutions during DEMETER’s lifetime: 3

Proposed benchmarking mechanism elaborated with participation of over 500 farmers	Water and pesticide usage per yield unit and per hectare: N/A
	Number of tools and datasets tried in pilots: 4 tools and 100 datasets

Objective #5 – User Oriented Solutions	
Running ‘challenges’ based on farmer needs.	Groups of suppliers teaming up to address needs expressed by farmers: WODR, AVINET, PSNC
Open co-creation space for suppliers to team up and answer farmer needs.	Number of farms addressed: 6

Objective #6 – Real World Impact	
Fully deployed DEMETER ecosystem	100 service advisors sign up to DEMETER: 3 service advisors.
	100 suppliers of solutions sign up to DEMETER: WODR, AVINET, PSNC
	Pilots deployed across 5 different sectors: Pilots deployed across 1 sector

Pilot 2.4 Benchmarking at Farm Level Decision Support System

Pilot 2.4 contributes to the general objectives: *O1*, *O2*, *O3*, *O4*.

Table 9: Pilot 2.4 contribution to general objectives and KPIs

Objective #1 – Information Modelling & Objective #2 – Knowledge Exchange Mechanisms	
Agriculture Interoperability Space deployed	DEMETER interoperability mechanisms implemented: Not defined yet
	Number of solutions present in DEMETER: eDWIN Farm management system - virtual farm, eDWIN eODR – system for advisors, 4 economical models like FADN algorithms for calculating the economic size of the farm and 1 benchmarking data service.
	Number of different suppliers involved in DEMETER: IERiGZ - Institute of Agriculture and Food Economics, PSNC, WODR, Frackowiak, Napierala
	Number of external components / data hubs connected to DEMETER: Eurostat, FADN EU, FADN PL, agro-market information
	New deployments at farmers: 5 small farms, 3 medium farms, 2 big farms
	Number of harmonization’s and contributions to standards: Harmonization of external datasets relevant for benchmarking like FADN, Eurostat, and potentially CAP. Contribution to AIM standardization
	Volume of data observing the information models:

	• Meteorological network of ~500 stations, each of it will have 24 readings per day: that gives 12 000 records per day (~1,1 GB per year) • FADN PL ~12 000 farms from which data will be derived (annually) • FADN EU ~ 4 GB • Eurostat (agri-related datasets) ~ 16GB

Objective #3 – Data Ownership	
Farm context model including inventory of data sources.	Available Model: AIM
New business models defined and adopted	Available Yes
Data exchange mechanisms implemented within DEMETER	Number of data exchanges: eDWIN (provider of farm data via REST API, AIM wrapper), benchmarking service (REST API, AIM wrapper), data preparation & integration enabler (REST API, AIM)
Exposure of farmer sourced data through DEMETER	Number of data sharing agreements: 10 (5 small, 3 medium, 2 big farms)

Objective #4 – Benchmarking	
Proposed benchmarking mechanism elaborated with participation of over 500 farmers	Comparison / selection of solutions during DEMETER's lifetime: 30
	Water and pesticide usage per yield unit and per hectare: N/A
	Number of tools and datasets tried in pilots: • FADN PL – dataset of farm production and economic data from polish farms • FADN EU – dataset of farm production and economic data from European farms (including polish) • Eurostat - subset of data related to agri-economic indicators • eDWIN (Virtual Farm) – Farm management system targeted at plant protection (including meteorological data) • Agro-market data – dataset to be built by advisory centres setting prices for products of agricultural origin

Pilot 3.1 Decision Support System to Support Olive Growers

Pilot 3.1 contributes to the general objectives: *O1, O2, O3, O4, O5.*

Table 10: Pilot 3.1 contribution to general objectives and KPIs

Objective #1 – Information Modelling & Objective #2 – Knowledge Exchange Mechanisms

Agriculture Interoperability Space deployed	DEMETER interoperability mechanisms implemented: FIWARE NGSIv2.
	Number of solutions present in DEMETER: OLIWES platform includes olive fruit fly DSS, water management DSS and nutrient DSS.
	Number of different suppliers involved in DEMETER: AGRICOLUS, VICOMTECH, DNET.
	Number of external components / data hubs connected to DEMETER: Currently available: Copernicus Sentinel 2, Copernicus ERA5, DAVIS weather stations, PESSL weather stations.
	New deployments at farmers: 8 olive farms (5 in Greece + 3 in Italy) already involved.
	Number of harmonization's and contributions to standards: ETSI NGSI-LD, FIWARE NGSIv2.
	Volume of data observing the information models: Sentinel 2 and Copernicus ERA5 data for the selected fields (~1GB for relevant fields), Weather station in selected farms (~100MB).

Objective #3 – Data Ownership	
Farm context model including inventory of data sources.	Available: Yes
New business models defined and adopted	Available: Pilot 3.1 will support creation of new business model.
Data exchange mechanisms implemented within DEMETER	Number of data exchanges: Not defined yet
Exposure of farmer sourced data through DEMETER	Number of data sharing agreements: Data sharing agreement with the involved farms will be defined.

Objective #4 – Benchmarking	
Proposed benchmarking mechanism elaborated with participation of over 500 farmers	Comparison / selection of solutions during DEMETER's lifetime: OLIWES Water management DSS, OLIWES Fertilisation DSS.
	Water and pesticide usage per yield unit and per hectare: We will compare the irrigation amount suggested by OLIWES Water DSS with the amount of the previous standard irrigation management. We need to stress that water consumption varies over the years due to different weather conditions.

	Number of tools and datasets tried in pilots: At least 4 tools and 10 datasets.

Objective #5 – User Oriented Solutions	
Running 'challenges' based on farmer needs.	Groups of suppliers teaming up to address needs expressed by farmers: AGRICOLUS, VICOMTECH, DNET, VITO.
Open co-creation space for suppliers to team up and answer farmer needs.	Number of farms addressed: 8 olive farms directly involved (we are planning to use the directly involved farms to connect with their own network farmers).

Pilot 3.2 Precision Farming for Mediterranean Woody Crops

Pilot 3.2 contributes to the general objectives: *O1, O2, O4*.

Table 11: Pilot 3.2 contribution to general objectives and KPIs

Objective #1 – Information Modelling & Objective #2 – Knowledge Exchange Mechanisms	
Agriculture Interoperability Space deployed	DEMETER interoperability mechanisms implemented: MQTT, FIWARE NGSIv2, ISOBUS.
	Number of solutions present in DEMETER: - AgIoT gateways for "in situ" data collection, in static spots and in ground machinery (Robots and Tractors) - OLIWES platform includes olive fruit fly DSS, water management DSS and nutrient DSS. (From Pilot 3.1) - Data visualization tools - Portuguese Datacentre at National Agrarian Institute (INIAV)
	Number of external components / data hubs connected to DEMETER: Copernicus Sentinel 2, Copernicus ERA5, IPMA weather stations.
	Number of different suppliers involved: Ubiwhere, Agricolus
	New deployments at farmers: 2 vineyards, one olive and apple trees already involved, though INIAV and FENADEGAS
	Number of harmonization's and contributions to standards: ETSI NGSI-LD, FIWARE NGSIv2
	Volume of data observing the information models: Sentinel 2 and Copernicus ERA5 data for the selected fields (~1GB for relevant fields), Local data from AgIoT gateways in selected farms (~1TB), namely: • Soil and Air temperature and humidity (daily) • Canopy imagens from ground stations • NDVI images from ground stations • Pest images (smart trap)

Objective #4 – Benchmarking	
Proposed benchmarking mechanism elaborated with participation of over 500 farmers	Comparison / selection of solutions during DEMETER's lifetime: OLIWES Water management DSS, OLIWES Fertilisation DSS
	Water and pesticide usage per yield unit and per hectare: We will compare the irrigation amount suggested by OLIWES Water DSS with the amount of the previous standard irrigation management. We need to stress that water consumption varies over the years due to different weather conditions.
	Number of tools and datasets tried in pilots: At least 4 tools and 10 datasets.

Pilot 3.3 Pest Management Control on Fruit Fly

Pilot 3.3 contributes to the general objectives: *O1, O2, O4*.

Table 12: Pilot 3.3 contribution to general objectives and KPIs

Objective #1 – Information Modelling and Objective #2 – Knowledge Exchange Mechanisms	
Agriculture Interoperability Space deployed	DEMETER interoperability mechanisms implemented: Not determined yet
	Number of solutions present in DEMETER: Computer vision-based counting module
	Number of different suppliers involved in DEMETER: TRAGSA and ATOS
	New deployments at farmers: Valencian Community region
	Volume of data observing the information models: More than 170.000 hectares are involved; the number of traps to be deployed is not determined yet.

Objective #4 – Benchmarking	
Proposed benchmarking mechanism elaborated with participation of over 500 farmers	Comparison / selection of solutions during DEMETER's lifetime: It is going to be compare with the solution that now it is in use.
	Water and pesticide usage per yield unit and per hectare: N/A. To control this pest, sterilize fly is going to be used, not pesticide.

Pilot 3.4 Open Platform for Improved Crop Monitoring in Potato Farms

Pilot 3.4 contributes to the general objectives: *O1, O2, O3, O4, O5*.

Table 13: Pilot 3.4 contribution to general objectives and KPIs

Objective #1 – Information Modelling & Objective #2 – Knowledge Exchange Mechanisms	
	DEMETER interoperability mechanisms implemented: NGSI-LD

Agriculture Interoperability Space deployed	Number of solutions present in DEMETER: WatchItGrow platform, includes yield prediction, variable rate application, crop mapping.
	Number of different suppliers involved in DEMETER: VITO, AVR.
	Number of external components / data hubs connected to DEMETER: Currently connected to WatchItGrow: AVR and "Bodemkundige Dienst van België". Available soon: John Deere Operations Center, ILVO DjustConnect.
	New deployments at farmers: None yet. First tests for pilot 3.4 will be done with 20-25 machines by 15-20 farmers.
	Number of harmonization's and contributions to standards: openEO
	Volume of data observing the information models: - Sentinel-1/2 data over Europe. - KMI meteorological data over Belgium, TWC meteorological data over Europe - AVR machinery data related to planting and harvest

Objective #3 – Data Ownership	
Farm context model including inventory of data sources.	Available: Yes
New business models defined and adopted	Available: Pilot 3.4 will support creation of new business models.
Data exchange mechanisms implemented within DEMETER	Number of data exchanges: None yet.
Exposure of farmer sourced data through DEMETER	Number of data sharing agreements: AVR data for research – if farmer agrees, to be specified in the contract with the farmer

Objective #4 – Benchmarking	
Proposed benchmarking mechanism elaborated with participation of over 500 farmers	Comparison / selection of solutions during DEMETER's lifetime: Not defined yet
	Water and pesticide usage per yield unit and per hectare: Only water usage benchmarking.
	Number of tools and datasets tried in pilots: To be determined.

Objective #5 – User Oriented Solutions	
Running 'challenges' based on farmer needs.	Groups of suppliers teaming up to address needs expressed by farmers: VITO and AVR, VITO and ELGO, VITO and Agricolus
Open co-creation space for suppliers to team up and answer farmer needs.	Number of farms addressed: First tests and solutions for pilot 3.4 will be done with 15-20 farmers. The numbers may increase in the next pilot rounds.

Pilot 4.1 Dairy Farmers Dashboard for the Entire Milk and Meat Production Value Chain

Pilot 4.1 contributes to the general objectives: *O1, O2, O3, O4, O5.*

Table 14: Pilot 4.1 contribution to general objectives and KPIs

Objective #1 – Information Modelling & Objective #2 – Knowledge Exchange Mechanisms	
Agriculture Interoperability Space deployed	DEMETER interoperability mechanisms implemented: API and systems not determined yet
	Number of solutions present in DEMETER: Eana Ku. App for production management in dairy farm. Other solutions not determined yet.
	Number of different suppliers involved in DEMETER: Mimiro and Landbrukets Dataflyt (Agricultural Dataflow).
	Number of external components / data hubs connected to DEMETER: NCDX and other solutions not determined yet.
	New deployments at farmers: More than 500 Norwegian farms.
	Number of harmonization's and contributions to standards: ICAR.
	Volume of data observing the information models: 20-25 MB per day

Objective #3 – Data Ownership	
Farm context model including inventory of data sources.	National herd recording system and Eana Ku
New business models defined and adopted	Not yet, but open to define new business models if they are discovered.
Data exchange mechanisms implemented within DEMETER	Number of data exchanges: Not determined yet.
Exposure of farmer sourced data through DEMETER	Number of data sharing agreements: Not determined yet.

Objective #4 – Benchmarking	
Proposed benchmarking mechanism elaborated with participation of over 500 farmers	Comparison / selection of solutions during DEMETER's lifetime: Solutions will be developed in the scope of WP4
	Weekly and monthly Milk production per animal and per herd Climatic accounting Mechanisms not determined yet.
	Number of tools and datasets tried in pilots >= 5.000 Datasets corresponding to IoT Gateways Production data coming from external datasets (NCDX) and IoT devices (milk fat and protein) Production and economic data from farmers and farm industry.

Objective #5 – User Oriented Solutions	
Running 'challenges' based on farmer needs.	Groups of suppliers teaming up to address needs expressed by farmers >= 30

Open co-creation space for suppliers to team up and answer farmer needs.	Number of farms addressed: Robot farms -> Number of milking cows = 32.000 and 570 dairy farms involved in Mimiros activity. More than 1000 Norwegian farms (potentially) involved in the broad dashboard activity.

Pilot 4.2 Consumer Awareness: Milk Quality and Animal Welfare Tracking

Pilot 4.2 contributes to the general objectives: *O1*, *O2*, *O3*, *O4*, *O5*.

Table 15: Pilot 4.2 contribution to general objectives and KPIs

Objective #1 – Information Modelling and Objective #2 – Knowledge Exchange Mechanisms	
Agriculture Interoperability Space deployed	DEMETER interoperability mechanisms implemented: FIWARE NGSIv2.
	Number of solutions present in DEMETER: Animal Welfare DSS, Traceability DSS, Benchmarking
	Number of different suppliers involved in DEMETER: ENG and ROT
	Number of external components / data hubs: Pedometer (rest of the animals monitoring), Datalog (animal temperature), Afilab (milk quality recognition), Aficollar (rumination, heating habits), MilkoBox (real-time milk analysis), MilkoScan (mikl traceability and off-line milk analysis)
	New deployments at farmers >= 30: Maccarese (breeding farm) and Latte Sano (milk processing company)
	Number of harmonization's and contributions to standards: ETSI NGSI-LD, FIWARE NGSIv2
	Volume of data observing the information models: Historical information of breeding farms and processing farm, as well as the corresponding indices that they generate.

Objective #3 – Data Ownership	
Farm context model including inventory of data sources.	Agricultural Information Model (AIM)
New business models defined and adopted	Although it is still too early in this stage of the project to define new business models, the interoperability capability provided by DEMETER will open new solutions based on the exchange of information among different supply chain actors.
Data exchange mechanisms implemented within DEMETER	Number of data exchanges: CSV file extracted from Farm's software devices
Exposure of farmer sourced data through DEMETER	Number of data sharing agreements: Maccarese (breeding farm) and Latte Sano (processing farm)

Objective #4 – Benchmarking

Proposed benchmarking mechanism elaborated with participation of over 500 farmers	Comparison / selection of solutions during DEMETER's lifetime: Applications that will be developed in the scope of the project
	Water and pesticide usage per yield unit: N/A.
	Number of tools and datasets tried in pilots: Pilot 4.2 counts on several devices, each of them producing datasets. From the side of Maccarese, wearable devices for animals (Pedometer, Milking robot, Data Log, AfiCollar) and Afilab software to control milk quality. From the side of Latte Sano (processing farm) technologies for the separation of dairy yield (AfiLab) to be applied to milking machines, automatic lactating devices (Milk Box MKII) to guarantee the traceability of the milk collected and MilkoScan FTIR to analyse the characteristics of all milk collected

Objective #5 – User Oriented Solutions	
Running 'challenges' based on farmer needs.	Groups of suppliers teaming up to address needs expressed by farmers: ENG and ROT
Open co-creation space for suppliers to team up and answer farmer needs.	Number of farms addressed: Maccarese is the largest Italian dairy farm (with 1450 Friesian dairy cows, 600 fattening calves and 3.240 hectares of land).

Pilot 4.3 Proactive Milk Quality Control

Pilot 4.3 contributes to the general objectives: *O1, O3, O4, O5*.

Table 16: Pilot 4.3 contribution to general objectives and KPIs

Objective #1 – Information Modelling & Objective #2 – Knowledge Exchange Mechanisms	
Agriculture Interoperability Space deployed	DEMETER interoperability mechanisms implemented: Not determined yet
	Number of different stakeholders involved: 4 farms
	New deployments at farmers: 4 farms
	Number of harmonization's and contributions to standards: -

Objective #3 – Data Ownership	
Farm context model including inventory of data sources.	Available: Yes
New business models defined and adopted	-
Data exchange mechanisms implemented within DEMETER	Data coming from Smartbow eartags. Animal identification, rumination time, grazing time, activity and movement.
Exposure of farmer sourced data through DEMETER	Data coming from Smartbow eartags. Animal identification, rumination time, grazing time, activity and movement.

Objective #4 – Benchmarking	
Proposed benchmarking mechanism elaborated with participation of over 500 farmers	Number of tools evaluated in pilot: Not determined yet
	Well-being of poultry increased by >= 15%

Objective #5 – User Oriented Solutions	
Running 'challenges' based on farmer needs.	Positive feedback about traceability tools > 90%
Open co-creation space for suppliers to team up and answer farmer needs.	Feedback for farmers and direct co-creation of service during pilot in more than 10 farms

Pilot 4.4 Optimal Chicken Farm Management

Pilot 4.4 contributes to the general objectives: *O1, O2, O3, O4, O5*.

Table 17: Pilot 4.4 contribution to general objectives and KPIs

Objective #1 – Information Modelling & Objective #2 – Knowledge Exchange Mechanisms	
Agriculture Interoperability Space deployed	DEMETER interoperability mechanisms implemented: MEGA, ETSI NGSI-LD and FIWARE NGSIv2.
	Number of different stakeholders involved: 10 farms
	New deployments at farmers: 10 (pilots and open calls)
	Number of harmonization's and contributions to standards >= 1 (GS1 compliant data standards used)

Objective #3 – Data Ownership	
Farm context model including inventory of data sources.	Available: Yes
New business models defined and adopted	Creation of new business model related to poultry well-being by introducing premium line of products
Data exchange mechanisms implemented within DEMETER	Number of data exchanges: NGSI, NGSI-LD y MEGA
Exposure of farmer sourced data through DEMETER	Data from 10 poultry farms including environmental and well-being data.

Objective #4 – Benchmarking	
Proposed benchmarking mechanism elaborated with participation of over 500 farmers	Number of tools evaluated in pilot >= 10
	Well-being of poultry increased by >= 15%

Objective #5 – User Oriented Solutions

Running 'challenges' based on farmer needs.	Positive feedback about traceability tools > 90%
Open co-creation space for suppliers to team up and answer farmer needs.	Feedback for farmers and direct co-creation of service during pilot in more than 10 farms

Pilot 5.1 Disease Prediction and Supply Chain Transparency for Orchards/Vineyards

Pilot 5.1 contributes to the general objectives: *O1*, *O2*, *O3*, *O4*, *O6*.

Table 18: Pilot 5.1 contribution to general objectives and KPIs

Objective #1 – Information Modelling and Objective #2 – Knowledge Exchange Mechanisms	
Agriculture Interoperability Space deployed	DEMETER interoperability mechanisms implemented: MEGA, ETSI NGSI-LD and FIWARE NGSIv2.
	Number of solutions present in DEMETER: Not defined yet
	Number of different suppliers involved in DEMETER: 14 vineyards in 4 countries
	Number of external components / data hubs: Not defined yet
	New deployments at farmers: Not defined yet
	Number of harmonization's and contributions to standards: GS1 compliant data standards used
	Volume of data observing the information models: Not defined yet

Objective #3 – Data Ownership	
Farm context model including inventory of data sources.	Available: Yes
New business models defined and adopted	Creation of new business model related additional data and data exchange between stakeholders
Data exchange mechanisms implemented within DEMETER	Number of data exchanges: Not determined yet
Exposure of farmer sourced data through DEMETER	Number of data sharing agreements: Data from 14 vineyards including environmental and transport data.

Objective #4 – Benchmarking	
Proposed benchmarking mechanism elaborated with participation of over 500 farmers	Comparison / selection of solutions during DEMETER's lifetime: Not defined yet
	Water and pesticide usage per yield unit and per hectare: Not defined yet

	Number of tools and datasets tried in pilots: More than 10 traceability mechanisms evaluated with farmers and stakeholders. More than 20 datasets.

Objective #6 – Real World Impact	
Fully deployed DEMETER ecosystem	100 service advisors sign up to DEMETER: Not determined yet
	100 suppliers of solutions sign up to DEMETER: Not defined yet
	Pilots deployed across 5 different sectors: Interoperable ecosystem deployed connecting all actors (Farmers, Retailers, Consumers, Agriculture machinery-robotics vendor) Introduced traceability in the ecosystem by writing most important data into the blockchain

Pilot 5.2 Farm of Things in Extensive Cattle Holdings

Pilot 5.2 contributes to the general objectives: *O1*, *O2*, *O3*, *O4*, *O6*.

Table 19: Pilot 5.2 contribution to general objectives and KPIs

Objective #1 – Information Modelling and Objective #2 – Knowledge Exchange Mechanisms	
Agriculture Interoperability Space deployed	DEMETER interoperability mechanisms implemented::AfarCloud Middleware (MQTT, OGC, REST, DDS), Farm Proxy
	Number of solutions present in DEMETER: Farmers' collaboration platform, Offering-demand sharing platform, App for product quality and user feedback, App for production management in livestock farm.
	Number of different suppliers involved in DEMETER: UPM, Centria, Tragsa, Tecnalia, Probot, Codan
	Number of external components / data hubs connected: OpenFoodfacts, AFarCloud Middleware
	New deployments at farmers: 3 or 4 dairy farms (Extremadura, Spain), 1 dairy farm (Kotipelto farm, Finland)
	Number of harmonization's and contributions to standards: No
	Volume of data observing the information models: 2.2 GB each 15 days.

Objective #3 – Data Ownership	
Farm context model including inventory of data sources.	Farm work organization and AFarCloud's information model
New business models defined and adopted	Not yet, but open to define new business models if they are discovered.
Data exchange mechanisms implemented within DEMETER	Number of data exchanges: The Marketplace apps will model these data exchange mechanisms

Exposure of farmer sourced data through DEMETER	Number of data sharing agreements: 3 or 4 dairy farms in Spain and 1 dairy farm in Finland involved in the pilots)

Objective #4 – Benchmarking	
Proposed benchmarking mechanism elaborated with participation of over 500 farmers	Comparison / selection of solutions during DEMETER's lifetime: 4 Applications that will be developed in the scope of the project
	Water and pesticide usage per yield unit and per hectare: Not applicable.
	Number of tools and datasets tried in pilots: • Datasets corresponding to IoT Gateways (e.g. AFarCloud Middleware, Farm Proxy) • Satellite imagery for map cartography • Product data coming from external datasets (e.g. milk data, environmental data)

Objective #6 – Real World Impact	
Fully deployed DEMETER ecosystem	100 service advisors sign up to DEMETER: Not determined yet
	100 suppliers of solutions sign up to DEMETER: UPM, Centria, Tragsa, Tecnalia, Probot, Codan
	Pilots deployed across 5 different sectors: Three sub-pilots or use cases described in the introduction of this section, related to animal wellness, production improvement and food traceability.

Pilot 5.3 Pollination Optimisation in Apiculture

Pilot 5.3 contributes to the general objectives: *O1, O2, O3, O6*.

Table 20: Pilot 5.3 contribution to general objectives and KPIs

Objective #1 – Information Modelling & Objective #2 – Knowledge Exchange Mechanisms	
Agriculture Interoperability Space deployed	DEMETER interoperability mechanisms implemented: Pilot5.3 adopts interoperability mechanisms and standards such as: REST, JSON, GeoJSON, Kafka message broker, JSON-LD (AIM)
	Number of solutions present in DEMETER: eDWIN, ControlBee, bee pollination optimization service (developed in DEMETER)
	Number of different suppliers involved in DEMETER: WODR, PSNC, IDEATRONIK
	Number of external components / data hubs: eDWIN, ControlBee
	New deployments at farmers : The pilot involves 4 beekeepers and 3 farmers in the Wielkopolska region in Poland.
	Number of harmonization's and contributions to standards: No

	Volume of data observing the information models: At the moment the pilot does not use large data volumes. Data to be used in the pilot include: - Farm data: 3 farms x 3 fields; 4 apiaries x 25 hives - Meteorological data: 140 stations x 24 readings per day - Apiary data: 100 hives sensors x 150 data records / day - Additionally, at the later stage of the project, it is considered to use the results of image processing and satellite data used by WPP4 DSS services.

Objective #3 – Data Ownership	
Farm context model including inventory of data sources.	Available
New business models defined and adopted	Available
Data exchange mechanisms implemented within DEMETER	Number of data exchanges: N/A
Exposure of farmer sourced data through DEMETER	Number of data sharing agreements: 7 (3 farmers and 4 beekeepers involved in the pilot)

Objective #6 – Real World Impact	
Fully deployed DEMETER ecosystem	100 service advisors sign up to DEMETER: 4 service advisors involved in the pilot

Pilot 5.4 Transparent Supply Chain in Poultry Industry

Pilot 5.4 contributes to the general objectives: *O1, O2, O3, O6*.

Table 21: Pilot 5.4 contribution to general objectives and KPIs

Objective #1 – Information Modelling & Objective #2 – Knowledge Exchange Mechanisms	
Agriculture Interoperability Space deployed	DEMETER interoperability mechanisms implemented: MEGA, ETSI NGSI-LD and FIWARE NGSIv2.
	Number of solutions present in DEMETER: Not determined yet
	Number of different suppliers involved: More than 15 (transport providers, retailers, consumers)
	New deployments at farmers: More than 10 (pilots and open calls).

	Not determined yet
	Number of external components / data hubs: Not defined yet
	New deployments at farmers: Not determined yet
	Number of harmonization’s and contributions to standards: GS1 compliant data standards used
	Volume of data observing the information models >= 20 exabytes Not determined yet

Objective #3 – Data Ownership	
Farm context model including inventory of data sources.	Available Yes
New business models defined and adopted	Creation of new business model related to poultry based on traceability and data exchange
Data exchange mechanisms implemented within DEMETER	Number of data exchanges: Not determined yet
Exposure of farmer sourced data through DEMETER	Data from 10 poultry farms including environmental and well-being data.

Objective #6 – Real World Impact	
Fully deployed DEMETER ecosystem	100 service advisors sign up to DEMETER: Not determined yet
	100 suppliers of solutions sign up to DEMETER: Introduced traceability in the ecosystem by writing most important data into the blockchain
	Pilots deployed across 5 different sectors: Interoperable ecosystem deployed connecting all actors (Farmers, Retailers, Consumers, Agriculture machinery-robotics vendor)

Annex 3 – Technical specification provided by specific pilot

Pilot 1.3 Smart Irrigation Service in Rice & Maize Cultivation

The technical specifications for each of the services provided in Figure 7: Overview of information flow for Pilot 1.3 and integration within DEMETER are shown in the following tables.

Table 22: Technical specification for services in Pilot 1.3

ID		AC-ELGO-1
Responsible partner		ELGO / ICCS
Component name		Smart Irrigation Service for Rice (SIS-Rice)
Functionalities offered		Determination of rice fields’ flooding (irrigation) needs based on data such as water salinity and height measurements Automatic control of input/output electric valves in rice paddies Provision of relevant notifications to users
Data input	Description	Salinity and water height measurements from IoT sensors; meteorological predictions (optional); satellite imagery (auxiliary)

	Format	JSON (for IoT sensor & meteorological predictions); GDAL-supported raster format (for satellite imagery)
	Standard adopted	RESTful HTTP API (for IoT sensor & meteorological predictions); GeoTIFF (for satellite imagery, converted internally)
Data output	Description	Structured SMS messages to electrical valves; SMS notifications to users
	Format	SMS
	Standard adopted	GSM
Integration requirements		Ingestion service for telemetry API; structured SMS creation

ID		AC-ELGO-2
Responsible partner		ELGO / ICCS
Component name		Smart Irrigation Service for Maize (SIS-Maize)
Functionalities offered		Estimation of maize fields' irrigation based on UAV-collected imagery Visualisation of irrigation prescription maps Provision of relevant notifications to users
Data input	Description	Thermal and multispectral imagery collected from UAVs
	Format	Sensor-specific; typically, GeoTIFF
	Standard adopted	GeoTIFF
Data output	Description	Irrigation prescription maps SMS notifications to users
	Format	geojson (or any other format needed)
	Standard adopted	GeoJSON specification
Integration requirements		Support for georeferenced vector file reading; structured SMS creation; Pix4Dmapper Pro if ortho-mosaicking processing is required to be performed on the server side

ID		AC-ELGO-3
Responsible partner		ELGO / ICCS
Component name		Fertilisation Advisory Service for Rice & Maize (FertiRM)
Functionalities offered		Estimation of rice or maize fields' nitrogen needs based on UAV-collected imagery Visualisation of irrigation prescription maps Provision of relevant notifications to users
Data input	Description	Multispectral imagery collected from UAVs of very high-resolution satellite sensors
	Format	Raster
	Standard adopted	GeoTIFF
Data output	Description	Fertilisation prescription maps SMS notifications to users
	Format	geojson (or any other format needed)
	Standard adopted	GeoJSON specification
Integration requirements		Support for georeferenced vector file reading; structured SMS creation; Pix4Dmapper Pro if ortho-mosaicking processing is required to be performed on the server side

Pilot 2.3 Data Brokerage Service and Decision Support System for Farm Management

Connectivity and Networking Infrastructures

Table 23: Connectivity and networking infrastructures for Pilot 2.3

Platform	Requirements
SensLog	Internet access. Needs to be accessible to HSLayersNG and OpenMicka. Exposed HTTP REST APIs at dedicated ports. Access to PostgreSQL database L3 connectivity to DB1 and DB2.
HSLayersNG	Internet access. Local connectivity to SensLog and OpenMicka. Access to PostgreSQL database
OpenMicka	Internet access. Local connectivity to HSLayersNG and SensLog. Access to PostgreSQL database ad Web server supporting PHP 7
Layman	Internet access. Local connectivity to HSLayersNG and OpenMicka Access to PostgreSQL database, Geoserver and Java

Pilot 3.2 Precision Farming for Mediterranean Woody Crops

Table 24: Specific documentation regarding data used in Pilot 3.2

Data name	**AgIoT device properties**	
JSON Data fields	**Description**	**Datatype/Units**
DeviceID	Unique Device ID	CHAR(18)
DevicePublicKey	Public Key	CHAR(128)
DeviceType	Describes the AgIoT devise, as Static (1) , attached to tractor (2), GateWay(3), attached to Robot(4)	Integer
DeviceLatitude	Device Location in Latitude	Float/degrees

DeviceLongitute	Device Location in Longitude	Float/degrees
DeviceAltitude	Device Location in Altitude	Float/meters
DeviceSensors	List of sensors types attached to AgIoT device	Array of integers
TimeSample	Time of data sample (since year 2020)	Float | milliseconds
Periodicity		
Min	Max	
1/day	10/sec	
Topic Name Format		
/(FarmGroupName)/(FarmType)/DevicesRegistration		

Data name	**Air Quality Data**	
JSON Data fields	**Description**	**Datatype/Units**
DeviceID	Device ID of AgIoT sensor	CHAR(18)
AirTemperature	Air temperature	Float/Celsius
AirHumidity	Air Humidity	Float/Percentual
AirCO2	Air quality	Float/Percentual
TimeSample	Time of data sample (since year 2020)	Float | milliseconds
Periodicity		
Min	Max	
1/day	1/30min	
Topic Name Format		
/(FarmGroupName)/(DeviceID)/(SensorID)/(SensorTypeName)		

Data name	**Weather data**	
JSON Data fields	**Description**	**Datatype/Units**
DeviceID	Device ID of AgIoT sensor	CHAR(18)
WindVelocity	Wind Velocity	Float | m/s
Precipitation	Percipitation values	Float | mm/s
AirPressure	Air Pressure	Float | Pascal
TimeSample	Time of data sample (since year 2020)	Float | milliseconds
Periodicity		
Min	Max	
1/day	1/30min	
Topic Name Format		
/(FarmGroupName)/(DeviceID)/(SensorID)/(SensorTypeName)		

Data name	**Radiation**	
JSON Data fields	**Description**	**Datatype/Units**
DeviceID	Device ID of AgIoT sensor	CHAR(18)

SunRadiation	Sun Radiation	Float | W/m2
TimeSample	Time of data sample (since year 2020)	Float | milliseconds
Periodicity		
Min	Max	
1/day	1/30min	
Topic Name Format		
/(FarmGroupName)/(DeviceID)/(SensorID)/(SensorTypeName)		

Data name	**Plant Grow Basic Status**	
JSON Data fields	**Description**	**Datatype/Units**
DeviceID	Device ID of AgIoT sensor	CHAR(18)
SapFlow	Sap Flow Values	Float | unit
TrunkDiameter	Trunk Diameter	Float | centimetre
LeafHumidity	Leaf Humidity	Float | Percentage
TimeSample	Time of data sample (since year 2020)	Float | milliseconds
Periodicity		
Min	Max	
1/day	1/10min	
Topic Name Format		
/(FarmGroupName)/(DeviceID)/(SensorID)/(SensorTypeName)		

Data name	**Optical Plant Grow Canopy**	
JSON Data fields	**Description**	**Datatype/Units**
DeviceID	Device ID of AgIoT sensor	CHAR(18)
CanopyImage	Camera image	Base64
CanopyDepth	Camera image	Base64
LeafHumidity	Leaf Humidity	Float | Percentage
TimeSample	Time of data sample (since year 2020)	Float | milliseconds
Periodicity		
Min	Max	
1/day	1/30min	
Topic Name Format		
/(FarmGroupName)/(DeviceID)/(SensorID)/(SensorTypeName)		

Data name	**Soil Basic Quality Data**	
JSON Data fields	**Description**	**Datatype | Units**
DeviceID	Device ID of AgIoT sensor	CHAR(18)
SoilTemperature	Soil temperature	Float | Celsius

SoilHumidity	Soil Humidity	Float | Percentual
SoilCondutivity	Soil Conductivity	Float | mS/cm
SensingDepth	Sensor depth value	Float | meters
TimeSample	Time of data sample (since year 2020)	Float | milliseconds
Periodicity		
Min	Max	
1/day	1/30min	
Topic Name Format		
/(FarmGroupName)/(DeviceID)/(SensorID)/(SensorTypeName)		

Data name	**Soil Nutrient Levels**	
JSON Data fields	**Description**	**Datatype | Units**
DeviceID	Device ID of AgIoT sensor	CHAR(18)
SoilNitrogen	Soil temp	Float | Kg/M3
SoilPhosphorus	Soil Humidity	Float | Kg/M3
SoilPotassium	Soil Conductivity	Float | Kg/M3
SensingDepth	Sensor depth value	Float | meters
TimeSample	Time of data sample (since year 2020)	Float | milliseconds
Periodicity		
Min	Max	
1/Month	1/day	
Topic Name Format		
/(FarmGroupName)/(DeviceID)/(SensorID)/(SensorTypeName)		

Data name	**Soil NPK application (Fertilization)**	
JSON Data fields	**Description**	**Datatype | Units**
DeviceID	Device ID of AgIoT sensor	CHAR(18)
SoilNitrogen	Soil Nitrogen application	Float | Kg/M3
SoilPhosphorus	Soil Phosphorus application	Float | Kg/M3
SoilPotassium	Soil Potassium application	Float | Kg/M3
SensingDepth	Sensor depth value	Float | meters
TimeSample	Time of data sample (since year 2020)	Float | milliseconds
Periodicity		
Min	Max	
1/Month	1/sec/15days	
Topic Name Format		
/(FarmGroupName)/(DeviceID)/(SensorID)/(SensorTypeName)		

Data name	**Spectral Sensor**	
JSON Data fields	**Description**	**Datatype | Units**

DeviceID	Device ID of AgIoT sensor	CHAR(18)
SpectralResponse	Spectral value	Array of Floats
InstalationType	How the sensor is installed	Integer
TimeSample	Time of data sample (since year 2020)	Float | milliseconds
Periodicity		
Min	Max	
1/Month	1/sec	
Topic Name Format		
/(FarmGroupName)/(DeviceID)/(SensorID)/(SensorTypeName)		

Data name	**Smart Trap**	
JSON Data fields	**Description**	**Datatype | Units**
DeviceID	Device ID of AgIoT sensor	CHAR(18)
SpectralResponse	Camera image	Base64
InstalationType	How the sensor is installed	Integer
ImageClassification	Image Class ID	Integer
TimeSample	Time of data sample (since year 2020)	Float | milliseconds
Periodicity		
Min	Max	
1/Month	1/sec	
Topic Name Format		
/(FarmGroupName)/(DeviceID)/(SensorID)/(SensorTypeName)		

Data name	**2D Data Maps**	
JSON Data fields	**Description**	**Datatype/Units**
DeviceID	Device ID of AgIoT sensor	CHAR(18)
2DImage	2D data Maps	Base64
DataType	Data type – 10 NDVI, 20 Soil Moister, 21 Soil N content, 22 Soil N content, 30 flours counter, 40 Canopy Size, 1000 Soil band 1 value, 1001 Soil band 2 value ..	integer
ImageScaleLat	Scale of image in Latitude axis	Float | meters/pixel
ImageScaleLon	Scale of image in Longitude axis	Float | meters/pixel
ImageCentreLat	Coordinates of image centre in Latitude axis	Float | Degrees
ImageCentreLon	Coordinates of image centre Longitude axis	Float | Degrees
TimeSample	Time of data sample (since year 2020)	Float | milliseconds

Periodicity	
Min	Max
1/Month	1/day
Topic Name Format	
/(FarmGroupName)/(DeviceID)/(SensorID)/(SensorTypeName)	

AgIoT consumes data according the next format:

Table 25: Specific documentation regarding the data consumed by AgIoT in Pilot 3.2

Data name	**2D Prescription Maps**	
JSON Data fields	**Description**	**Datatype/Units**
DeviceID	Device ID of AgIoT sensor	CHAR(18)
2DImage	2D data Maps	Base64
DataType	Data type – 21 Soil N target, 22 Soil P target ….	integer
ImageScaleLat	Scale of image in Latitude axis	Float | meters/pixel
ImageScaleLon	Scale of image in Longitude axis	Float | meters/pixel
ImageCentreLat	Coordinates of image centre in Latitude axis	Float | Degrees
ImageCentreLon	Coordinates of image centre Longitude axis	Float | Degrees
TimeSample	Time of data sample (since year 2020)	Float | milliseconds
Periodicity		
Min	Max	
1/Month	1/day	
Topic Name Format		
/(FarmGroupName)/(DeviceID)/PrescriptionMapType		

Pilot 4.3 Proactive Milk Quality Control

Table 26: Technical specification of the information used by Pilot 4.3

Data Source Name and ID	
Data Short Description	Data coming from Smartbow eartags Animal identification, rumination time, grazing time, activity and movement
Dataset Type	File

Data Source Name and ID		
Purpose in Pilot	To examine the effectiveness of these cow behaviour characteristics as indicators of welfare and health of dairy cows	
Dataset Owner	TEAGASC	
Dataset Provider	ZOETIS	
Access License		
Access rights for DEMETER	For pilot activities purposes	
Dataset Access	Linked to dataset	
Version		
Spatial coverage		
Temporal coverage	24/7	
Resolution	Minute	
Volume	TBD	
Velocity	TBD	
Variety	sources of structured data • Animal ID: animal identification • Rumination time: length of time that animal ruminates for • Grazing time: length of time that animal grazes for • Activity and movement: number of steps taken and change in position of animal	
Veracity	The data will be meaningful to the problem being analysed but will show variation due to the individual animal effect	
Validity	Yes, Smartbow have published on this topic	
Volatility	Data will remain valid and can be stored indefinitely if required	
Data format	csv,	
Encryption	Zoetis may have their own encryption system.	
Data structure description	Aminal ID; Date; Group; Grazing time; Rumination time; Steps; Position;	
For unusual format, tool to read it	Not unusual format	
Remote accessibility	Yes Zoetis will provide access	
	Protocol	SNMP, CMIP, CoAP, NETCONF
	Message format	Protocol specific, JSON, XML (* use extra space if needed *)
	Pull/Push	Pull, push
	Provided interface	URI + interface specification (* use extra space if needed *)
If data is not yet accessible, how can they be retrieved?	Describe the architecture and where an agent can be deployed	Zoetis will provide
	Agent development requirements	Programming language, framework
	Usable software API on device	Are there usable APIs? (if yes, describe them and add reference to the documentation)
Dataset generation	Was the data monitored in a system with real users?	Yes

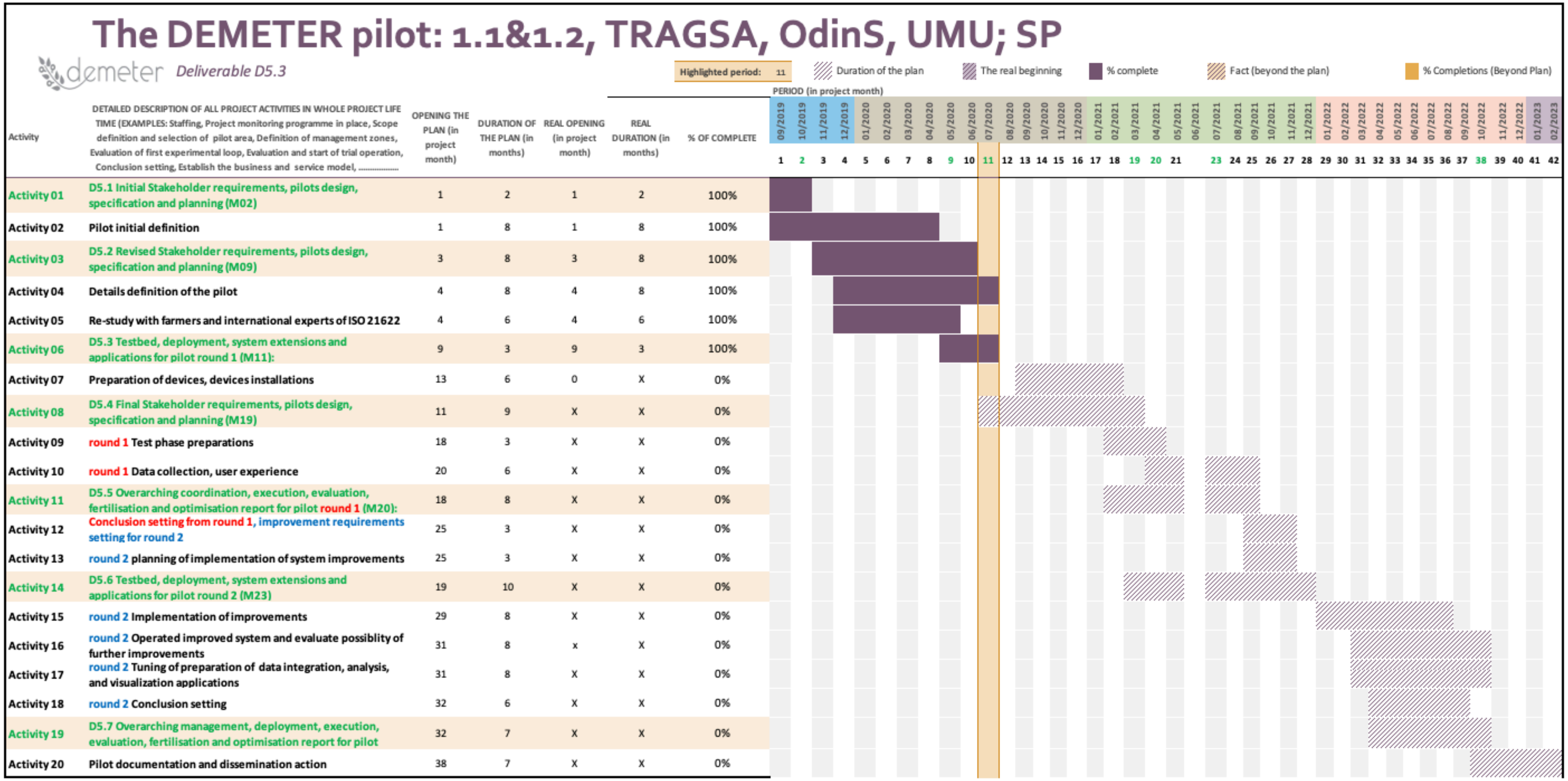
Data Source Name and ID		
	If no, how the data has been generated?	Actions triggered /performed/simulated, how many of them, methodology
Sample of data	Provide a sample of data here or a link to it	

Data Source Name and ID		
Data Short Description	Milk data Milk yield, composition and conductivity	
Dataset Type	File,	
Purpose in Pilot	To correlate against welfare/health measures	
Dataset Owner	TEAGASC	
Dataset Provider	LELY	
Access License		
Access rights for DEMETER	For pilot activities purpose	
Dataset Access	Link to dataset	
Version		
Spatial coverage		
Temporal coverage	24/7	
Resolution	Every milking	
Volume	TBD	
Velocity	TBD	
Variety	Milk yield: amount of milk produced per animal Milk composition: composition (fat & protein) of milk produced per animal Milk conductivity: conductivity of milk produced per animal	
Veracity	The data will be meaningful to the problem being analysed but will show variation due to the individual animal effect	
Validity	YES – data collected by LELY on on-going basis is validated	
Volatility	Data will remain valid and can be stored indefinitely if re	
Data format	csv,	
Encryption	Lely may have their own encrytion	
Data structure description	Animal ID; Date; Time; milk yield; milk fat; milk protein; milk conductivity	
For unusual format, tool to read it	Normal format	
Remote accessibility	Yes – lely do provide access	
	Protocol	SNMP, CMIP, CoAP, NETCONF
	Message format	Protocol specific, JSON, XML (* use extra space if needed *)
	Pull/Push	Pull, push
	Provided interface	URI + interface specification (* use extra space if needed *)
	Describe the architecture and where an agent can be deployed	lely will provide access

Data Source Name and ID		
If data is not yet accessible, how can they be retrieved?	Agent development requirements	Programming language, framework
	Usable software API on device	Are there usable APIs? (if yes, describe them and add reference to the documentation)
Dataset generation	Was the data monitored in a system with real users?	Yes/No
	If no, how the data has been generated?	Actions triggered /performed/simulated, how many of them, methodology
Sample of data	Provide a sample of data here or a link to it	

Annex 4 – Implementation plans

Pilot 1.1&1.2 Water Savings and Smart Energy Management in Irrigated Crops& Arable Crops



The DEMETER pilot: 1.1&1.2, TRAGSA, OdinS, UMU; SP

Deliverable D5.3

Highlighted period: 11

▨ Duration of the plan
▨ The real beginning
■ % complete
▨ Fact (beyond the plan)
■ % Completions (Beyond Plan)

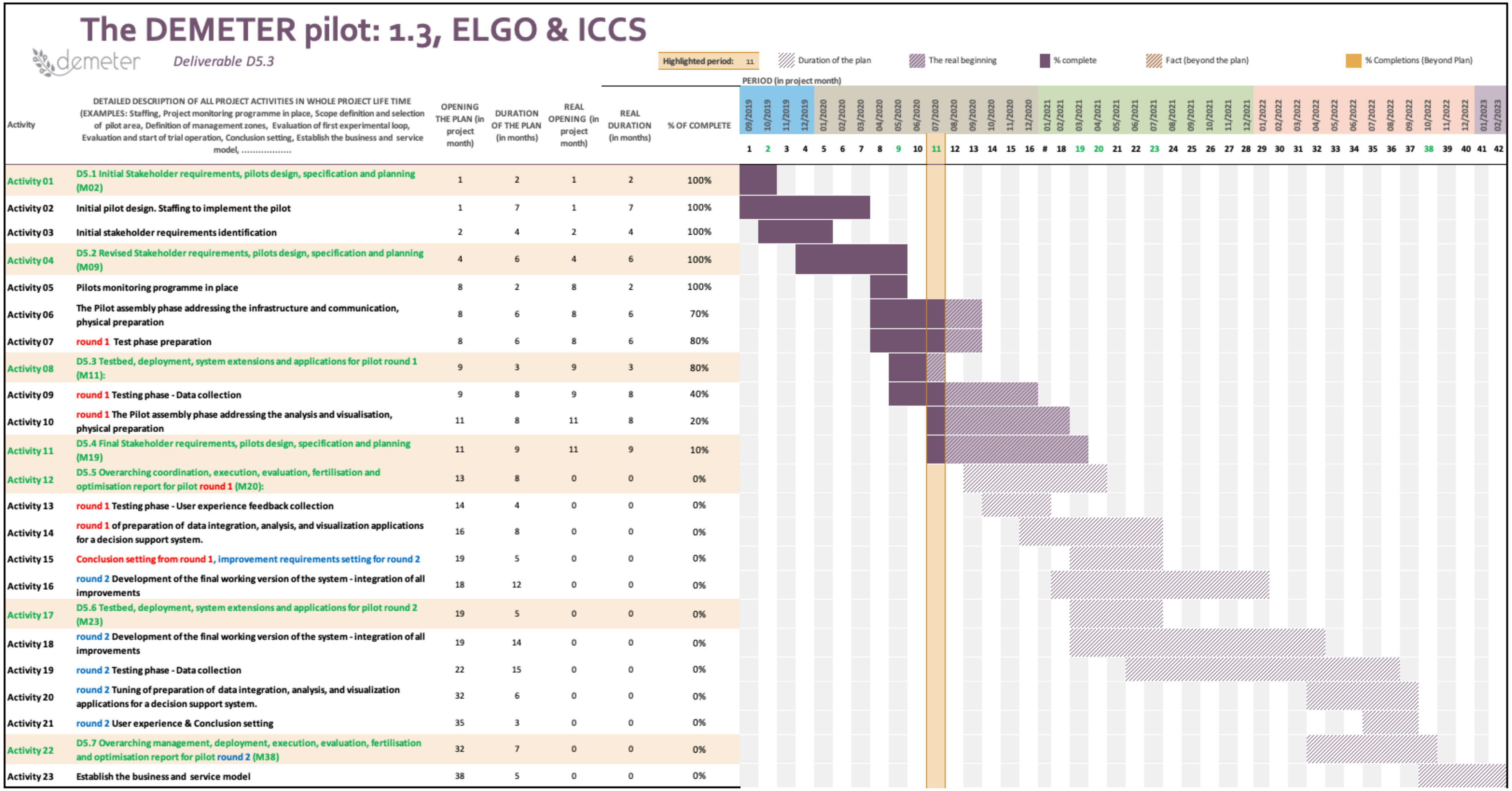
PERIOD (in project month)

09/2019 10/2019 11/2019 12/2019 01/2020 02/2020 03/2020 04/2020 05/2020 06/2020 07/2020 08/2020 09/2020 10/2020 11/2020 12/2020 01/2021 02/2021 03/2021 04/2021 05/2021 06/2021 07/2021 08/2021 09/2021 10/2021 11/2021 12/2021 01/2022 02/2022 03/2022 04/2022 05/2022 06/2022 07/2022 08/2022 09/2022 10/2022 11/2022 12/2022 01/2023 02/2023

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42

Activity	DETAILED DESCRIPTION OF ALL PROJECT ACTIVITIES IN WHOLE PROJECT LIFE TIME (EXAMPLES: Staffing, Project monitoring programme in place, Scope definition and selection of pilot area, Definition of management zones, Evaluation of first experimental loop, Evaluation and start of trial operation, Conclusion setting, Establish the business and service model, ...	OPENING THE PLAN (in project month)	DURATION OF THE PLAN (in months)	REAL OPENING (in project month)	REAL DURATION (in months)	% OF COMPLETE
Activity 01	D5.1 Initial Stakeholder requirements, pilots design, specification and planning (M02)	1	2	1	2	100%
Activity 02	Pilot initial definition	1	8	1	8	100%
Activity 03	D5.2 Revised Stakeholder requirements, pilots design, specification and planning (M09)	3	8	3	8	100%
Activity 04	Details definition of the pilot	4	8	4	8	100%
Activity 05	Re-study with farmers and international experts of ISO 21622	4	6	4	6	100%
Activity 06	D5.3 Testbed, deployment, system extensions and applications for pilot round 1 (M11):	9	3	9	3	100%
Activity 07	Preparation of devices, devices installations	13	6	0	X	0%
Activity 08	D5.4 Final Stakeholder requirements, pilots design, specification and planning (M19)	11	9	X	X	0%
Activity 09	round 1 Test phase preparations	18	3	X	X	0%
Activity 10	round 1 Data collection, user experience	20	6	X	X	0%
Activity 11	D5.5 Overarching coordination, execution, evaluation, fertilisation and optimisation report for pilot round 1 (M20):	18	8	X	X	0%
Activity 12	Conclusion setting from round 1, improvement requirements setting for round 2	25	3	X	X	0%
Activity 13	round 2 planning of implementation of system improvements	25	3	X	X	0%
Activity 14	D5.6 Testbed, deployment, system extensions and applications for pilot round 2 (M23)	19	10	X	X	0%
Activity 15	round 2 Implementation of improvements	29	8	X	X	0%
Activity 16	round 2 Operated improved system and evaluate possiblity of further improvements	31	8	x	X	0%
Activity 17	round 2 Tuning of preparation of data integration, analysis, and visualization applications	31	8	X	X	0%
Activity 18	round 2 Conclusion setting	32	6	X	X	0%
Activity 19	D5.7 Overarching management, deployment, execution, evaluation, fertilisation and optimisation report for pilot	32	7	X	X	0%
Activity 20	Pilot documentation and dissemination action	38	7	X	X	0%

Pilot 1.3 Smart Irrigation Service in Rice & Maize Cultivation



The DEMETER pilot: 1.3, ELGO & ICCS

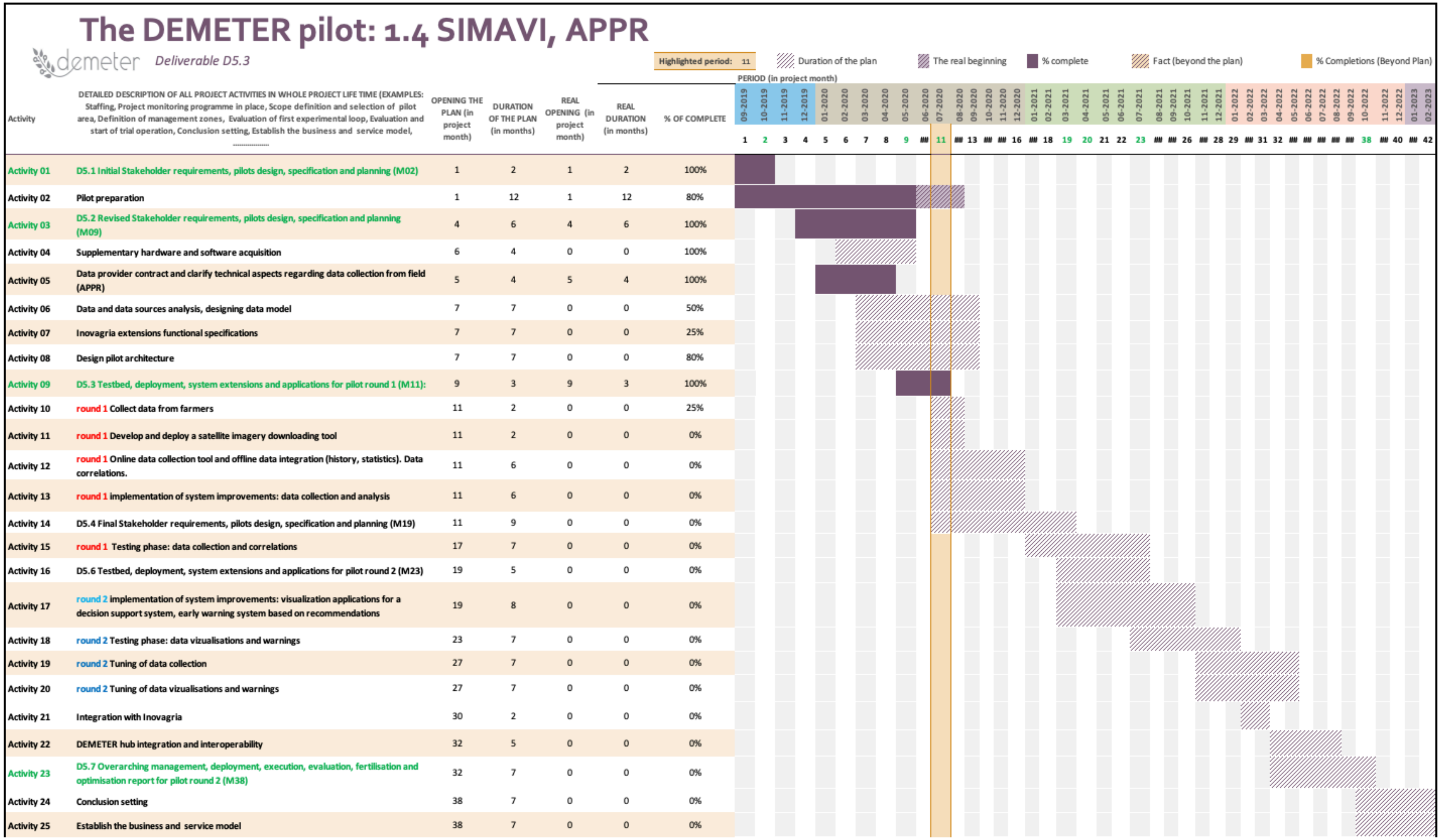
demeter *Deliverable D5.3*

Highlighted period: 11

▨ Duration of the plan ▨ The real beginning ■ % complete ▨ Fact (beyond the plan) ■ % Completions (Beyond Plan)

Activity	DETAILED DESCRIPTION OF ALL PROJECT ACTIVITIES IN WHOLE PROJECT LIFE TIME (EXAMPLES: Staffing, Project monitoring programme in place, Scope definition and selection of pilot area, Definition of management zones, Evaluation of first experimental loop, Evaluation and start of trial operation, Conclusion setting, Establish the business and service model, ...	OPENING THE PLAN (in project month)	DURATION OF THE PLAN (in months)	REAL OPENING (in project month)	REAL DURATION (in months)	% OF COMPLETE
Activity 01	D5.1 Initial Stakeholder requirements, pilots design, specification and planning (M02)	1	2	1	2	100%
Activity 02	Initial pilot design. Staffing to implement the pilot	1	7	1	7	100%
Activity 03	Initial stakeholder requirements identification	2	4	2	4	100%
Activity 04	D5.2 Revised Stakeholder requirements, pilots design, specification and planning (M09)	4	6	4	6	100%
Activity 05	Pilots monitoring programme in place	8	2	8	2	100%
Activity 06	The Pilot assembly phase addressing the infrastructure and communication, physical preparation	8	6	8	6	70%
Activity 07	round 1 Test phase preparation	8	6	8	6	80%
Activity 08	D5.3 Testbed, deployment, system extensions and applications for pilot round 1 (M11):	9	3	9	3	80%
Activity 09	round 1 Testing phase - Data collection	9	8	9	8	40%
Activity 10	round 1 The Pilot assembly phase addressing the analysis and visualisation, physical preparation	11	8	11	8	20%
Activity 11	D5.4 Final Stakeholder requirements, pilots design, specification and planning (M19)	11	9	11	9	10%
Activity 12	D5.5 Overarching coordination, execution, evaluation, fertilisation and optimisation report for pilot round 1 (M20):	13	8	0	0	0%
Activity 13	round 1 Testing phase - User experience feedback collection	14	4	0	0	0%
Activity 14	round 1 of preparation of data integration, analysis, and visualization applications for a decision support system.	16	8	0	0	0%
Activity 15	Conclusion setting from round 1, improvement requirements setting for round 2	19	5	0	0	0%
Activity 16	round 2 Development of the final working version of the system - integration of all improvements	18	12	0	0	0%
Activity 17	D5.6 Testbed, deployment, system extensions and applications for pilot round 2 (M23)	19	5	0	0	0%
Activity 18	round 2 Development of the final working version of the system - integration of all improvements	19	14	0	0	0%
Activity 19	round 2 Testing phase - Data collection	22	15	0	0	0%
Activity 20	round 2 Tuning of preparation of data integration, analysis, and visualization applications for a decision support system.	32	6	0	0	0%
Activity 21	round 2 User experience & Conclusion setting	35	3	0	0	0%
Activity 22	D5.7 Overarching management, deployment, execution, evaluation, fertilisation and optimisation report for pilot round 2 (M38)	32	7	0	0	0%
Activity 23	Establish the business and service model	38	5	0	0	0%

Pilot 1.4 IoT Corn Management & Decision Support Platform



The DEMETER pilot: 1.4 SIMAVI, APPR

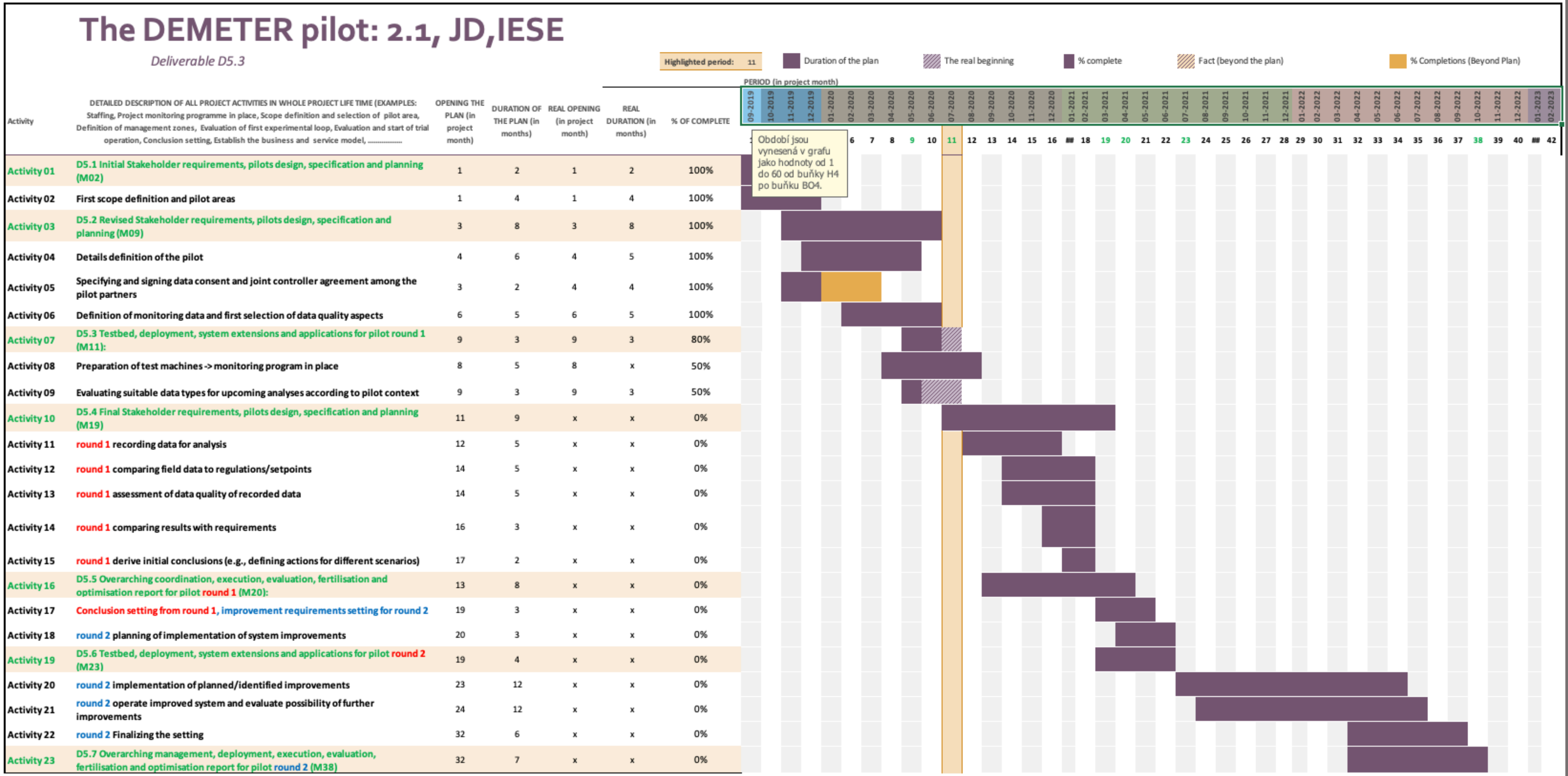
Deliverable D5.3

Highlighted period: 11

▨ Duration of the plan ▨ The real beginning ■ % complete ▨ Fact (beyond the plan) ■ % Completions (Beyond Plan)

Activity	DETAILED DESCRIPTION OF ALL PROJECT ACTIVITIES IN WHOLE PROJECT LIFE TIME (EXAMPLES: Staffing, Project monitoring programme in place, Scope definition and selection of pilot area, Definition of management zones, Evaluation of first experimental loop, Evaluation and start of trial operation, Conclusion setting, Establish the business and service model, ...	OPENING THE PLAN (in project month)	DURATION OF THE PLAN (in months)	REAL OPENING (in project month)	REAL DURATION (in months)	% OF COMPLETE
Activity 01	D5.1 Initial Stakeholder requirements, pilots design, specification and planning (M02)	1	2	1	2	100%
Activity 02	Pilot preparation	1	12	1	12	80%
Activity 03	D5.2 Revised Stakeholder requirements, pilots design, specification and planning (M09)	4	6	4	6	100%
Activity 04	Supplementary hardware and software acquisition	6	4	0	0	100%
Activity 05	Data provider contract and clarify technical aspects regarding data collection from field (APPR)	5	4	5	4	100%
Activity 06	Data and data sources analysis, designing data model	7	7	0	0	50%
Activity 07	Inovagria extensions functional specifications	7	7	0	0	25%
Activity 08	Design pilot architecture	7	7	0	0	80%
Activity 09	D5.3 Testbed, deployment, system extensions and applications for pilot round 1 (M11):	9	3	9	3	100%
Activity 10	round 1 Collect data from farmers	11	2	0	0	25%
Activity 11	round 1 Develop and deploy a satellite imagery downloading tool	11	2	0	0	0%
Activity 12	round 1 Online data collection tool and offline data integration (history, statistics). Data correlations.	11	6	0	0	0%
Activity 13	round 1 implementation of system improvements: data collection and analysis	11	6	0	0	0%
Activity 14	D5.4 Final Stakeholder requirements, pilots design, specification and planning (M19)	11	9	0	0	0%
Activity 15	round 1 Testing phase: data collection and correlations	17	7	0	0	0%
Activity 16	D5.6 Testbed, deployment, system extensions and applications for pilot round 2 (M23)	19	5	0	0	0%
Activity 17	round 2 implementation of system improvements: visualization applications for a decision support system, early warning system based on recommendations	19	8	0	0	0%
Activity 18	round 2 Testing phase: data vizualisations and warnings	23	7	0	0	0%
Activity 19	round 2 Tuning of data collection	27	7	0	0	0%
Activity 20	round 2 Tuning of data vizualisations and warnings	27	7	0	0	0%
Activity 21	Integration with Inovagria	30	2	0	0	0%
Activity 22	DEMETER hub integration and interoperability	32	5	0	0	0%
Activity 23	D5.7 Overarching management, deployment, execution, evaluation, fertilisation and optimisation report for pilot round 2 (M38)	32	7	0	0	0%
Activity 24	Conclusion setting	38	7	0	0	0%
Activity 25	Establish the business and service model	38	7	0	0	0%

Pilot 2.1 In-Service Condition Monitoring of Agricultural Machinery

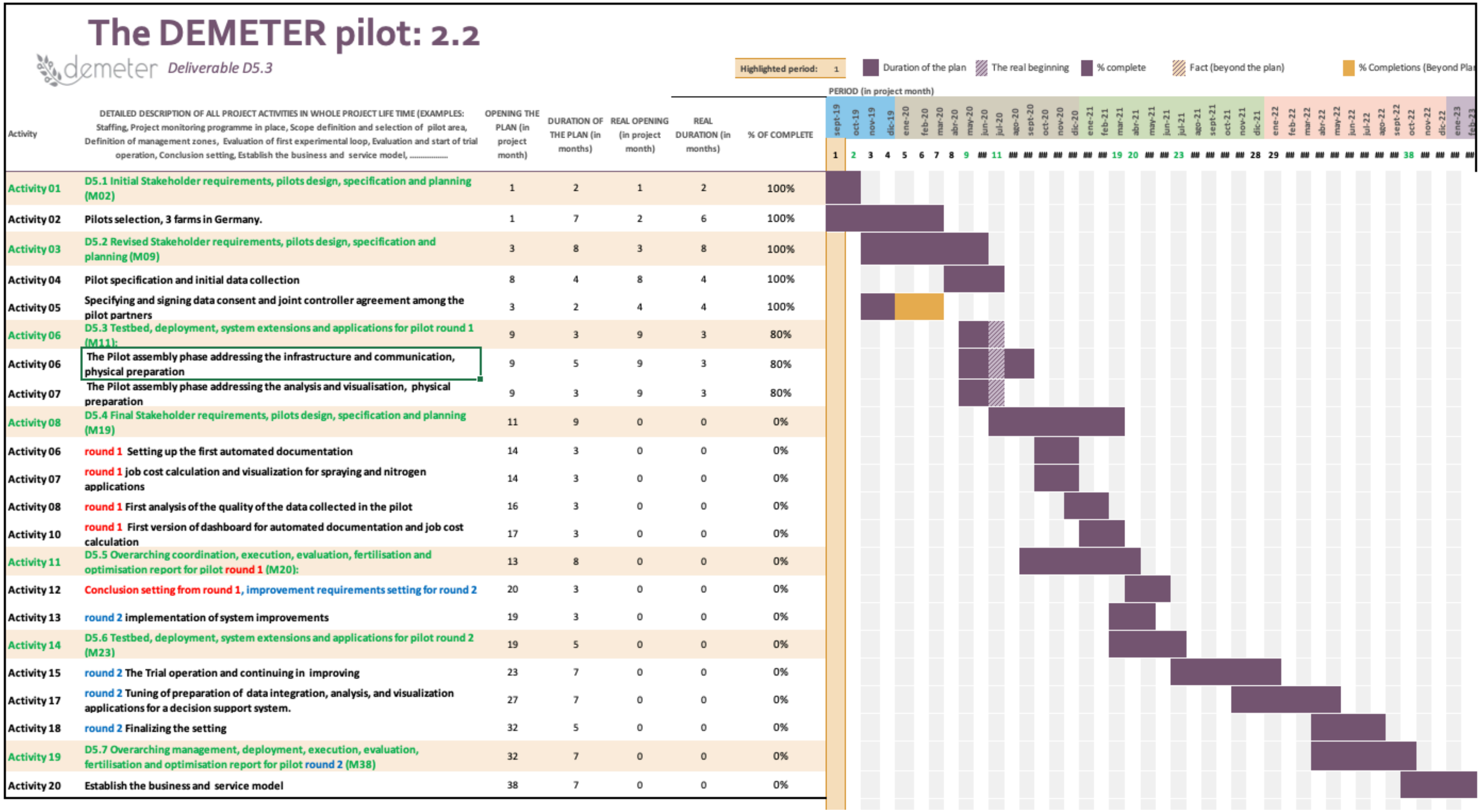


The DEMETER pilot: 2.1, JD,IESE

Deliverable D5.3

Activity	DETAILED DESCRIPTION OF ALL PROJECT ACTIVITIES IN WHOLE PROJECT LIFE TIME (EXAMPLES: Staffing, Project monitoring programme in place, Scope definition and selection of pilot area, Definition of management zones, Evaluation of first experimental loop, Evaluation and start of trial operation, Conclusion setting, Establish the business and service model, ...	OPENING THE PLAN (in project month)	DURATION OF THE PLAN (in months)	REAL OPENING (in project month)	REAL DURATION (in months)	% OF COMPLETE
Activity 01	D5.1 Initial Stakeholder requirements, pilots design, specification and planning (M02)	1	2	1	2	100%
Activity 02	First scope definition and pilot areas	1	4	1	4	100%
Activity 03	D5.2 Revised Stakeholder requirements, pilots design, specification and planning (M09)	3	8	3	8	100%
Activity 04	Details definition of the pilot	4	6	4	5	100%
Activity 05	Specifying and signing data consent and joint controller agreement among the pilot partners	3	2	4	4	100%
Activity 06	Definition of monitoring data and first selection of data quality aspects	6	5	6	5	100%
Activity 07	D5.3 Testbed, deployment, system extensions and applications for pilot round 1 (M11):	9	3	9	3	80%
Activity 08	Preparation of test machines -> monitoring program in place	8	5	8	x	50%
Activity 09	Evaluating suitable data types for upcoming analyses according to pilot context	9	3	9	3	50%
Activity 10	D5.4 Final Stakeholder requirements, pilots design, specification and planning (M19)	11	9	x	x	0%
Activity 11	round 1 recording data for analysis	12	5	x	x	0%
Activity 12	round 1 comparing field data to regulations/setpoints	14	5	x	x	0%
Activity 13	round 1 assessment of data quality of recorded data	14	5	x	x	0%
Activity 14	round 1 comparing results with requirements	16	3	x	x	0%
Activity 15	round 1 derive initial conclusions (e.g., defining actions for different scenarios)	17	2	x	x	0%
Activity 16	D5.5 Overarching coordination, execution, evaluation, fertilisation and optimisation report for pilot round 1 (M20):	13	8	x	x	0%
Activity 17	Conclusion setting from round 1, improvement requirements setting for round 2	19	3	x	x	0%
Activity 18	round 2 planning of implementation of system improvements	20	3	x	x	0%
Activity 19	D5.6 Testbed, deployment, system extensions and applications for pilot round 2 (M23)	19	4	x	x	0%
Activity 20	round 2 implementation of planned/identified improvements	23	12	x	x	0%
Activity 21	round 2 operate improved system and evaluate possibility of further improvements	24	12	x	x	0%
Activity 22	round 2 Finalizing the setting	32	6	x	x	0%
Activity 23	D5.7 Overarching management, deployment, execution, evaluation, fertilisation and optimisation report for pilot round 2 (M38)	32	7	x	x	0%

Pilot 2.2 Automated Documentation of Arable Crop Farming Processes



The DEMETER pilot: 2.2

Deliverable D5.3

Highlighted period: 1

▇ Duration of the plan ▨ The real beginning ▇ % complete ▨ Fact (beyond the plan) ▇ % Completions (Beyond Pla

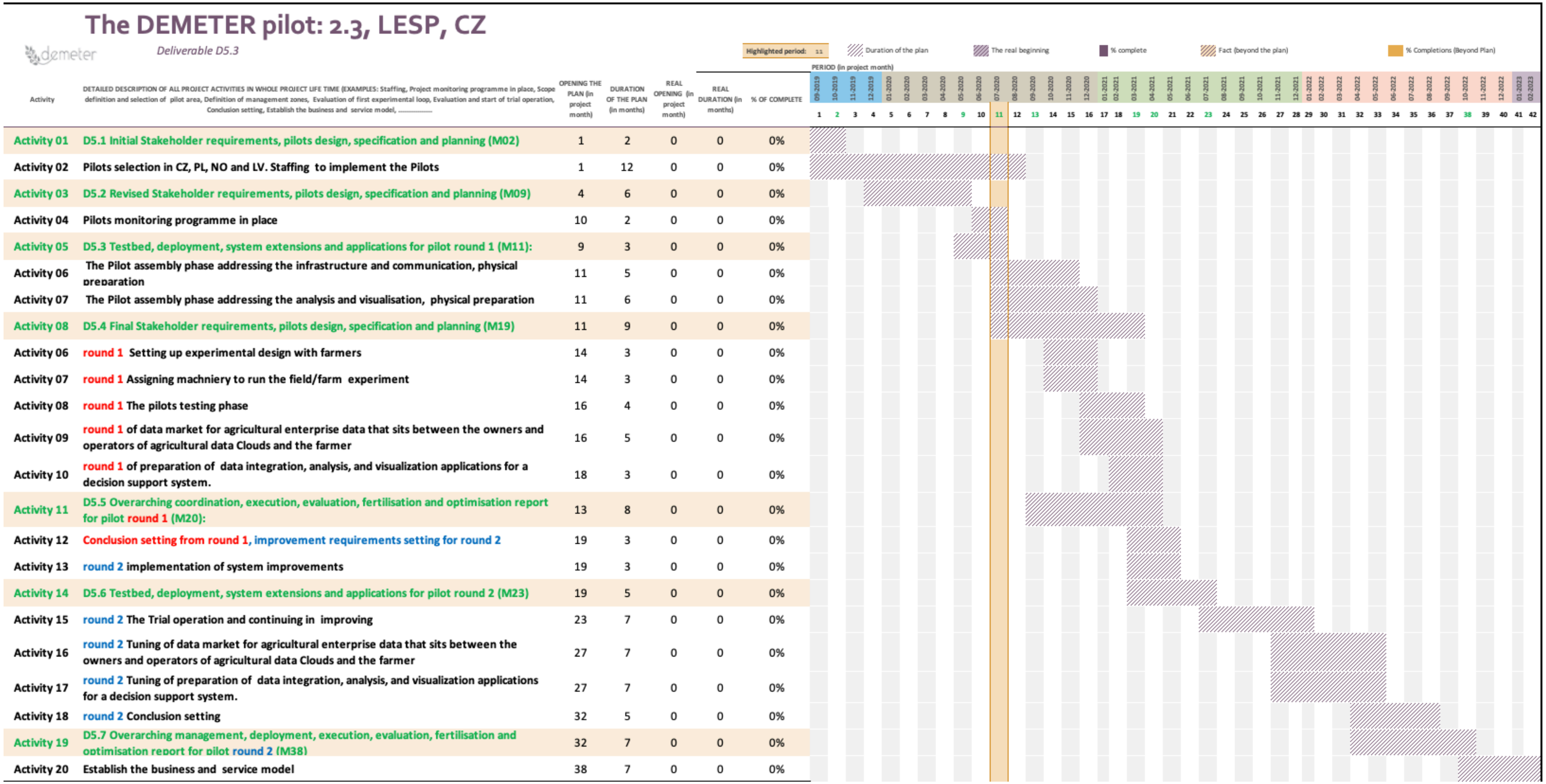
PERIOD (in project month)

sept-19 oct-19 nov-19 dic-19 ene-20 feb-20 mar-20 abr-20 may-20 jun-20 jul-20 ago-20 sept-20 oct-20 nov-20 dic-20 ene-21 feb-21 mar-21 abr-21 may-21 jun-21 jul-21 ago-21 sept-21 oct-21 nov-21 dic-21 ene-22 feb-22 mar-22 abr-22 may-22 jun-22 jul-22 ago-22 sept-22 oct-22 nov-22 dic-22 ene-23 feb-23

1 2 3 4 5 6 7 8 9 ## 11 ## ## ## ## ## ## ## 19 20 ## ## 23 ## ## ## ## 28 29 ## ## ## ## ## ## ## ## 38 ## ## ## ##

Activity	DETAILED DESCRIPTION OF ALL PROJECT ACTIVITIES IN WHOLE PROJECT LIFE TIME (EXAMPLES: Staffing, Project monitoring programme in place, Scope definition and selection of pilot area, Definition of management zones, Evaluation of first experimental loop, Evaluation and start of trial operation, Conclusion setting, Establish the business and service model, ...	OPENING THE PLAN (in project month)	DURATION OF THE PLAN (in months)	REAL OPENING (in project month)	REAL DURATION (in months)	% OF COMPLETE
Activity 01	D5.1 Initial Stakeholder requirements, pilots design, specification and planning (M02)	1	2	1	2	100%
Activity 02	Pilots selection, 3 farms in Germany.	1	7	2	6	100%
Activity 03	D5.2 Revised Stakeholder requirements, pilots design, specification and planning (M09)	3	8	3	8	100%
Activity 04	Pilot specification and initial data collection	8	4	8	4	100%
Activity 05	Specifying and signing data consent and joint controller agreement among the pilot partners	3	2	4	4	100%
Activity 06	D5.3 Testbed, deployment, system extensions and applications for pilot round 1 (M11):	9	3	9	3	80%
Activity 06	The Pilot assembly phase addressing the infrastructure and communication, physical preparation	9	5	9	3	80%
Activity 07	The Pilot assembly phase addressing the analysis and visualisation, physical preparation	9	3	9	3	80%
Activity 08	D5.4 Final Stakeholder requirements, pilots design, specification and planning (M19)	11	9	0	0	0%
Activity 06	round 1 Setting up the first automated documentation	14	3	0	0	0%
Activity 07	round 1 job cost calculation and visualization for spraying and nitrogen applications	14	3	0	0	0%
Activity 08	round 1 First analysis of the quality of the data collected in the pilot	16	3	0	0	0%
Activity 10	round 1 First version of dashboard for automated documentation and job cost calculation	17	3	0	0	0%
Activity 11	D5.5 Overarching coordination, execution, evaluation, fertilisation and optimisation report for pilot round 1 (M20):	13	8	0	0	0%
Activity 12	Conclusion setting from round 1, improvement requirements setting for round 2	20	3	0	0	0%
Activity 13	round 2 implementation of system improvements	19	3	0	0	0%
Activity 14	D5.6 Testbed, deployment, system extensions and applications for pilot round 2 (M23)	19	5	0	0	0%
Activity 15	round 2 The Trial operation and continuing in improving	23	7	0	0	0%
Activity 17	round 2 Tuning of preparation of data integration, analysis, and visualization applications for a decision support system.	27	7	0	0	0%
Activity 18	round 2 Finalizing the setting	32	5	0	0	0%
Activity 19	D5.7 Overarching management, deployment, execution, evaluation, fertilisation and optimisation report for pilot round 2 (M38)	32	7	0	0	0%
Activity 20	Establish the business and service model	38	7	0	0	0%

Pilot 2.3 Data Brokerage Service and Decision Support System for Farm Management



The DEMETER pilot: 2.3, LESP, CZ

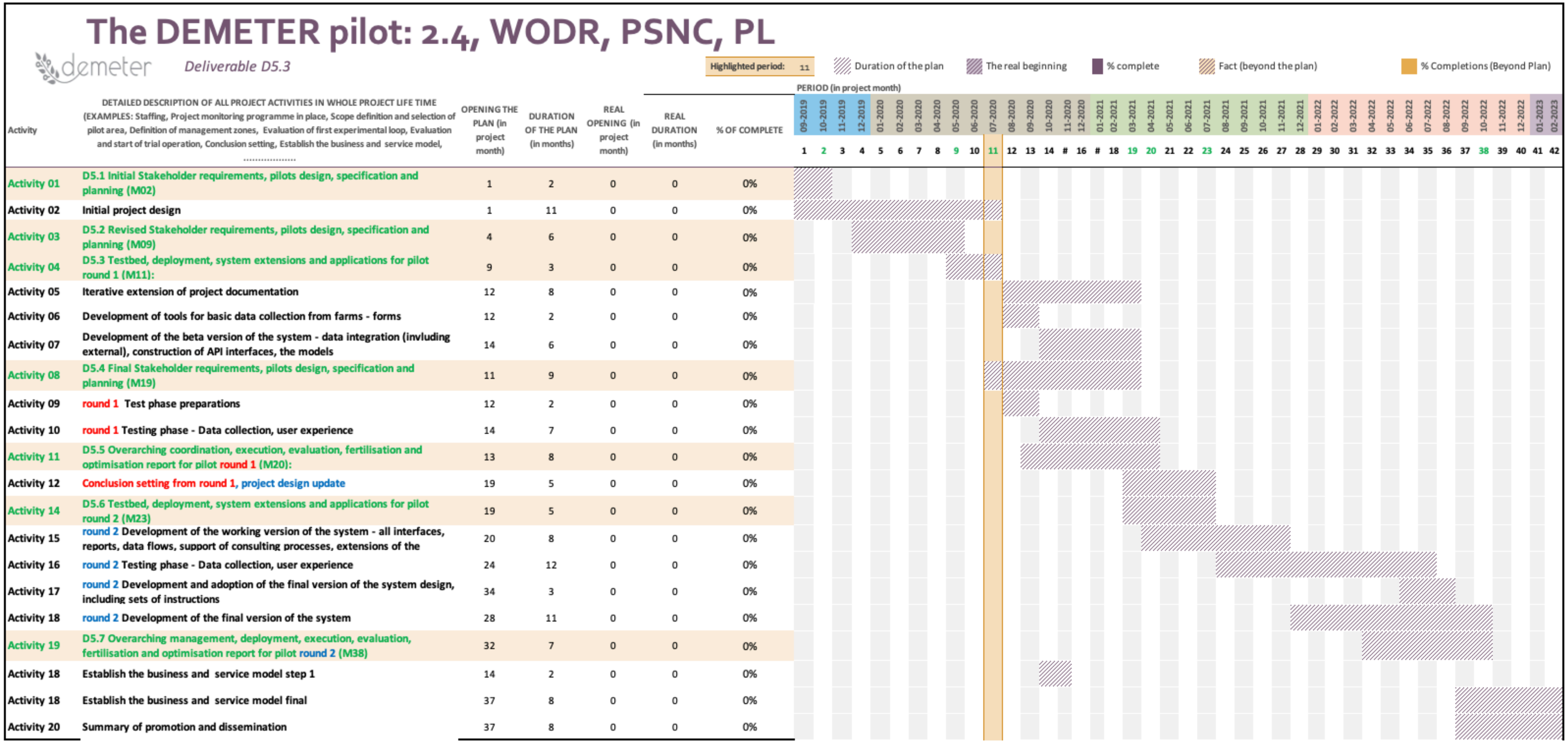
Deliverable D5.3

Highlighted period: 11 ▨ Duration of the plan ▨ The real beginning ■ % complete ▨ Fact (beyond the plan) ■ % Completions (Beyond Plan)

PERIOD (in project month)

Activity	DETAILED DESCRIPTION OF ALL PROJECT ACTIVITIES IN WHOLE PROJECT LIFE TIME (EXAMPLES: Staffing, Project monitoring programme in place, Scope definition and selection of pilot area, Definition of management zones, Evaluation of first experimental loop, Evaluation and start of trial operation, Conclusion setting, Establish the business and service model, ...	OPENING THE PLAN (in project month)	DURATION OF THE PLAN (in months)	REAL OPENING (in project month)	REAL DURATION (in months)	% OF COMPLETE
Activity 01	D5.1 Initial Stakeholder requirements, pilots design, specification and planning (M02)	1	2	0	0	0%
Activity 02	Pilots selection in CZ, PL, NO and LV. Staffing to implement the Pilots	1	12	0	0	0%
Activity 03	D5.2 Revised Stakeholder requirements, pilots design, specification and planning (M09)	4	6	0	0	0%
Activity 04	Pilots monitoring programme in place	10	2	0	0	0%
Activity 05	D5.3 Testbed, deployment, system extensions and applications for pilot round 1 (M11):	9	3	0	0	0%
Activity 06	The Pilot assembly phase addressing the infrastructure and communication, physical preparation	11	5	0	0	0%
Activity 07	The Pilot assembly phase addressing the analysis and visualisation, physical preparation	11	6	0	0	0%
Activity 08	D5.4 Final Stakeholder requirements, pilots design, specification and planning (M19)	11	9	0	0	0%
Activity 06	round 1 Setting up experimental design with farmers	14	3	0	0	0%
Activity 07	round 1 Assigning machniery to run the field/farm experiment	14	3	0	0	0%
Activity 08	round 1 The pilots testing phase	16	4	0	0	0%
Activity 09	round 1 of data market for agricultural enterprise data that sits between the owners and operators of agricultural data Clouds and the farmer	16	5	0	0	0%
Activity 10	round 1 of preparation of data integration, analysis, and visualization applications for a decision support system.	18	3	0	0	0%
Activity 11	D5.5 Overarching coordination, execution, evaluation, fertilisation and optimisation report for pilot round 1 (M20):	13	8	0	0	0%
Activity 12	Conclusion setting from round 1, improvement requirements setting for round 2	19	3	0	0	0%
Activity 13	round 2 implementation of system improvements	19	3	0	0	0%
Activity 14	D5.6 Testbed, deployment, system extensions and applications for pilot round 2 (M23)	19	5	0	0	0%
Activity 15	round 2 The Trial operation and continuing in improving	23	7	0	0	0%
Activity 16	round 2 Tuning of data market for agricultural enterprise data that sits between the owners and operators of agricultural data Clouds and the farmer	27	7	0	0	0%
Activity 17	round 2 Tuning of preparation of data integration, analysis, and visualization applications for a decision support system.	27	7	0	0	0%
Activity 18	round 2 Conclusion setting	32	5	0	0	0%
Activity 19	D5.7 Overarching management, deployment, execution, evaluation, fertilisation and optimisation report for pilot round 2 (M38)	32	7	0	0	0%
Activity 20	Establish the business and service model	38	7	0	0	0%

Pilot 2.4 Benchmarking at Farm Level Decision Support System



The DEMETER pilot: 2.4, WODR, PSNC, PL

Deliverable D5.3

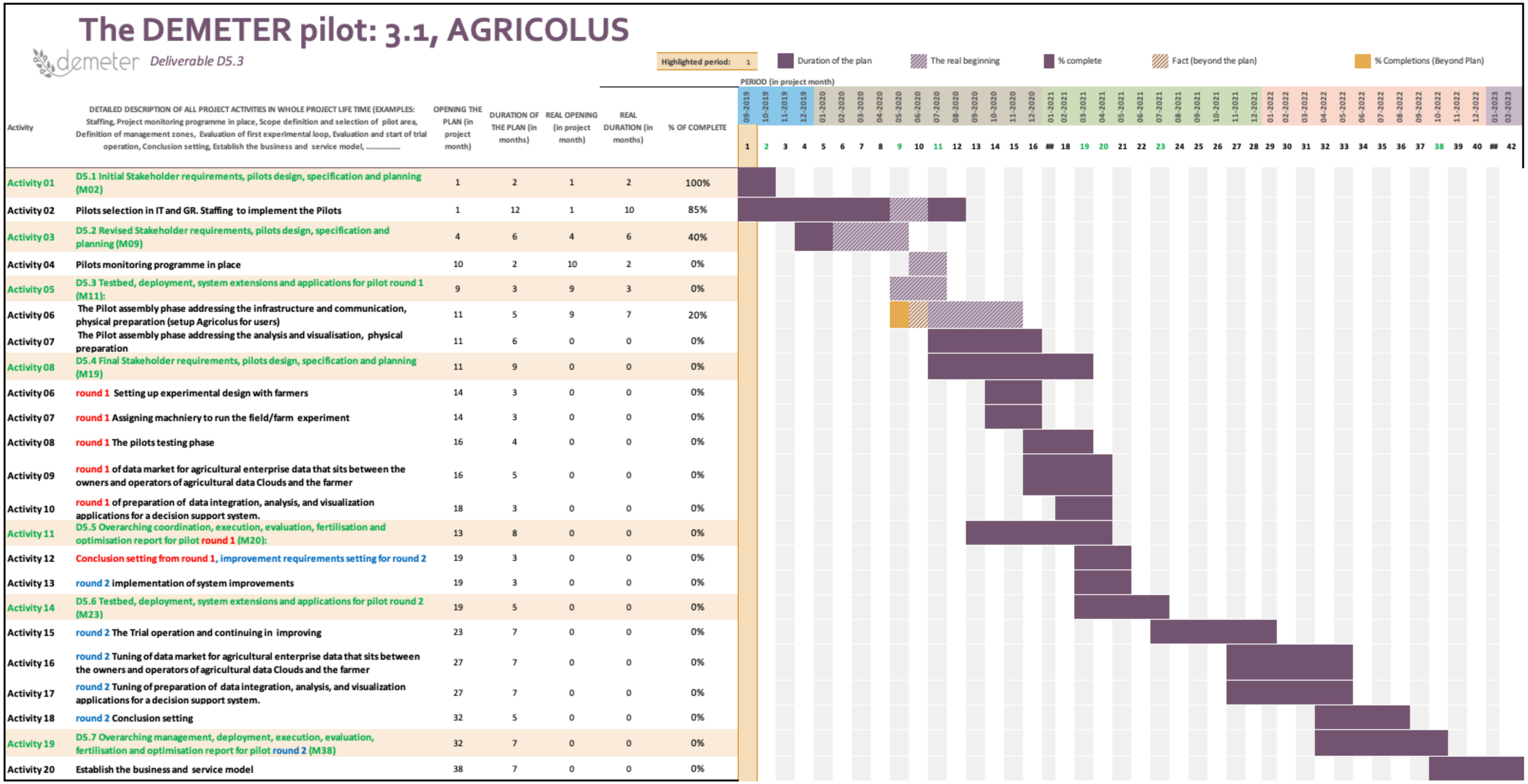
Highlighted period: 11

▨ Duration of the plan ▨ The real beginning ■ % complete ▨ Fact (beyond the plan) ■ % Completions (Beyond Plan)

PERIOD (in project month)

Activity	DETAILED DESCRIPTION OF ALL PROJECT ACTIVITIES IN WHOLE PROJECT LIFE TIME (EXAMPLES: Staffing, Project monitoring programme in place, Scope definition and selection of pilot area, Definition of management zones, Evaluation of first experimental loop, Evaluation and start of trial operation, Conclusion setting, Establish the business and service model, ...	OPENING THE PLAN (in project month)	DURATION OF THE PLAN (in months)	REAL OPENING (in project month)	REAL DURATION (in months)	% OF COMPLETE
Activity 01	D5.1 Initial Stakeholder requirements, pilots design, specification and planning (M02)	1	2	0	0	0%
Activity 02	Initial project design	1	11	0	0	0%
Activity 03	D5.2 Revised Stakeholder requirements, pilots design, specification and planning (M09)	4	6	0	0	0%
Activity 04	D5.3 Testbed, deployment, system extensions and applications for pilot round 1 (M11):	9	3	0	0	0%
Activity 05	Iterative extension of project documentation	12	8	0	0	0%
Activity 06	Development of tools for basic data collection from farms - forms	12	2	0	0	0%
Activity 07	Development of the beta version of the system - data integration (invluding external), construction of API interfaces, the models	14	6	0	0	0%
Activity 08	D5.4 Final Stakeholder requirements, pilots design, specification and planning (M19)	11	9	0	0	0%
Activity 09	round 1 Test phase preparations	12	2	0	0	0%
Activity 10	round 1 Testing phase - Data collection, user experience	14	7	0	0	0%
Activity 11	D5.5 Overarching coordination, execution, evaluation, fertilisation and optimisation report for pilot round 1 (M20):	13	8	0	0	0%
Activity 12	Conclusion setting from round 1, project design update	19	5	0	0	0%
Activity 14	D5.6 Testbed, deployment, system extensions and applications for pilot round 2 (M23)	19	5	0	0	0%
Activity 15	round 2 Development of the working version of the system - all interfaces, reports, data flows, support of consulting processes, extensions of the	20	8	0	0	0%
Activity 16	round 2 Testing phase - Data collection, user experience	24	12	0	0	0%
Activity 17	round 2 Development and adoption of the final version of the system design, including sets of instructions	34	3	0	0	0%
Activity 18	round 2 Development of the final version of the system	28	11	0	0	0%
Activity 19	D5.7 Overarching management, deployment, execution, evaluation, fertilisation and optimisation report for pilot round 2 (M38)	32	7	0	0	0%
Activity 18	Establish the business and service model step 1	14	2	0	0	0%
Activity 18	Establish the business and service model final	37	8	0	0	0%
Activity 20	Summary of promotion and dissemination	37	8	0	0	0%

Pilot 3.1 Decision Support System to Support Olive Growers



The DEMETER pilot: 3.1, AGRICOLUS

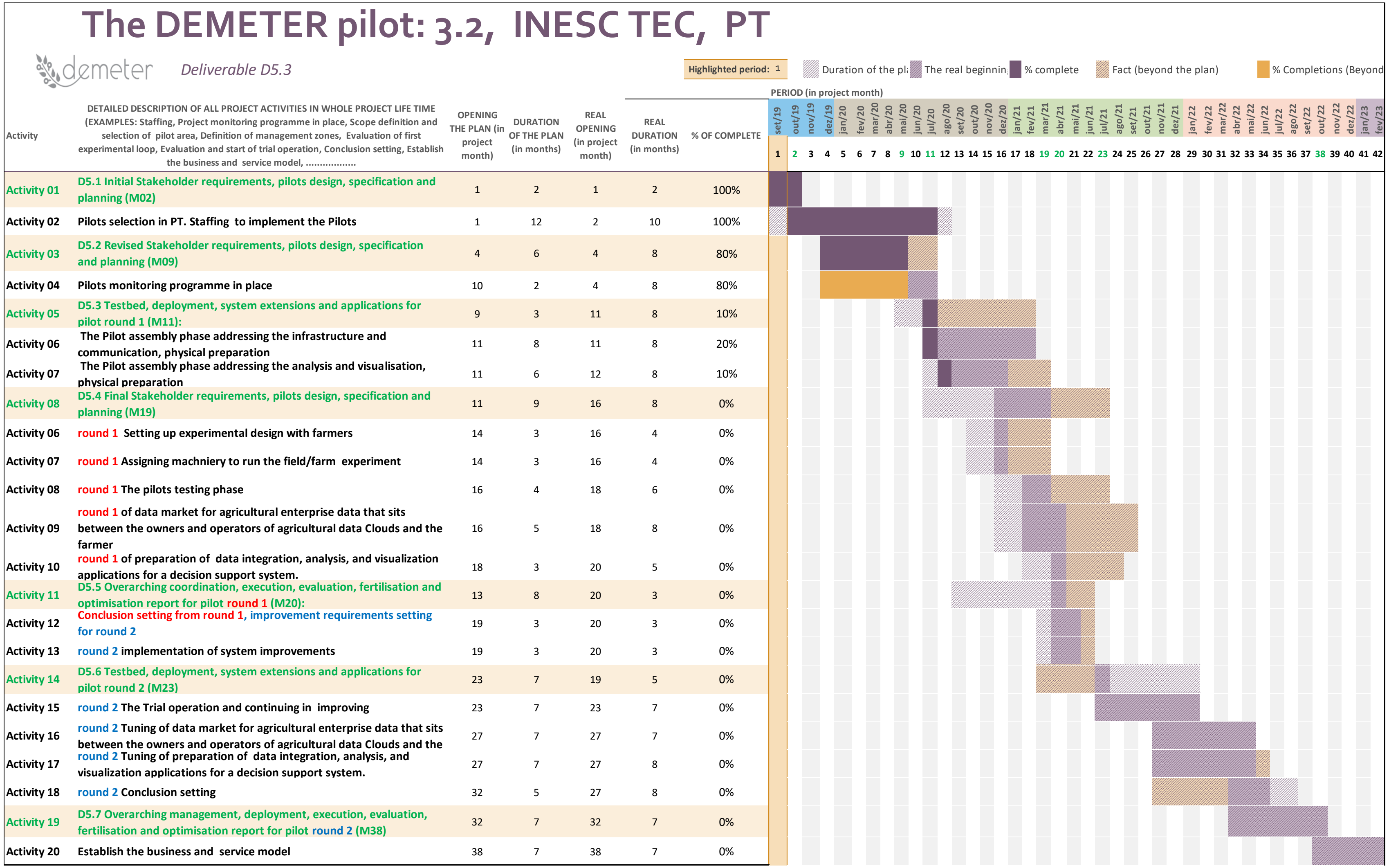
Deliverable D5.3

Highlighted period: 1

▇ Duration of the plan ▨ The real beginning ▇ % complete ▨ Fact (beyond the plan) 🟧 % Completions (Beyond Plan)

Activity	DETAILED DESCRIPTION OF ALL PROJECT ACTIVITIES IN WHOLE PROJECT LIFE TIME (EXAMPLES: Staffing, Project monitoring programme in place, Scope definition and selection of pilot area, Definition of management zones, Evaluation of first experimental loop, Evaluation and start of trial operation, Conclusion setting, Establish the business and service model, ...	OPENING THE PLAN (in project month)	DURATION OF THE PLAN (in months)	REAL OPENING (in project month)	REAL DURATION (in months)	% OF COMPLETE
Activity 01	D5.1 Initial Stakeholder requirements, pilots design, specification and planning (M02)	1	2	1	2	100%
Activity 02	Pilots selection in IT and GR. Staffing to implement the Pilots	1	12	1	10	85%
Activity 03	D5.2 Revised Stakeholder requirements, pilots design, specification and planning (M09)	4	6	4	6	40%
Activity 04	Pilots monitoring programme in place	10	2	10	2	0%
Activity 05	D5.3 Testbed, deployment, system extensions and applications for pilot round 1 (M11):	9	3	9	3	0%
Activity 06	The Pilot assembly phase addressing the infrastructure and communication, physical preparation (setup Agricolus for users)	11	5	9	7	20%
Activity 07	The Pilot assembly phase addressing the analysis and visualisation, physical preparation	11	6	0	0	0%
Activity 08	D5.4 Final Stakeholder requirements, pilots design, specification and planning (M19)	11	9	0	0	0%
Activity 06	round 1 Setting up experimental design with farmers	14	3	0	0	0%
Activity 07	round 1 Assigning machniery to run the field/farm experiment	14	3	0	0	0%
Activity 08	round 1 The pilots testing phase	16	4	0	0	0%
Activity 09	round 1 of data market for agricultural enterprise data that sits between the owners and operators of agricultural data Clouds and the farmer	16	5	0	0	0%
Activity 10	round 1 of preparation of data integration, analysis, and visualization applications for a decision support system.	18	3	0	0	0%
Activity 11	D5.5 Overarching coordination, execution, evaluation, fertilisation and optimisation report for pilot round 1 (M20):	13	8	0	0	0%
Activity 12	Conclusion setting from round 1, improvement requirements setting for round 2	19	3	0	0	0%
Activity 13	round 2 implementation of system improvements	19	3	0	0	0%
Activity 14	D5.6 Testbed, deployment, system extensions and applications for pilot round 2 (M23)	19	5	0	0	0%
Activity 15	round 2 The Trial operation and continuing in improving	23	7	0	0	0%
Activity 16	round 2 Tuning of data market for agricultural enterprise data that sits between the owners and operators of agricultural data Clouds and the farmer	27	7	0	0	0%
Activity 17	round 2 Tuning of preparation of data integration, analysis, and visualization applications for a decision support system.	27	7	0	0	0%
Activity 18	round 2 Conclusion setting	32	5	0	0	0%
Activity 19	D5.7 Overarching management, deployment, execution, evaluation, fertilisation and optimisation report for pilot round 2 (M38)	32	7	0	0	0%
Activity 20	Establish the business and service model	38	7	0	0	0%

Pilot 3.2 Precision Farming for Mediterranean Woody Crops



The DEMETER pilot: 3.2, INESC TEC, PT

Deliverable D5.3

Highlighted period: 1

▨ Duration of the pl ▨ The real beginnin ■ % complete ▨ Fact (beyond the plan) ■ % Completions (Beyond

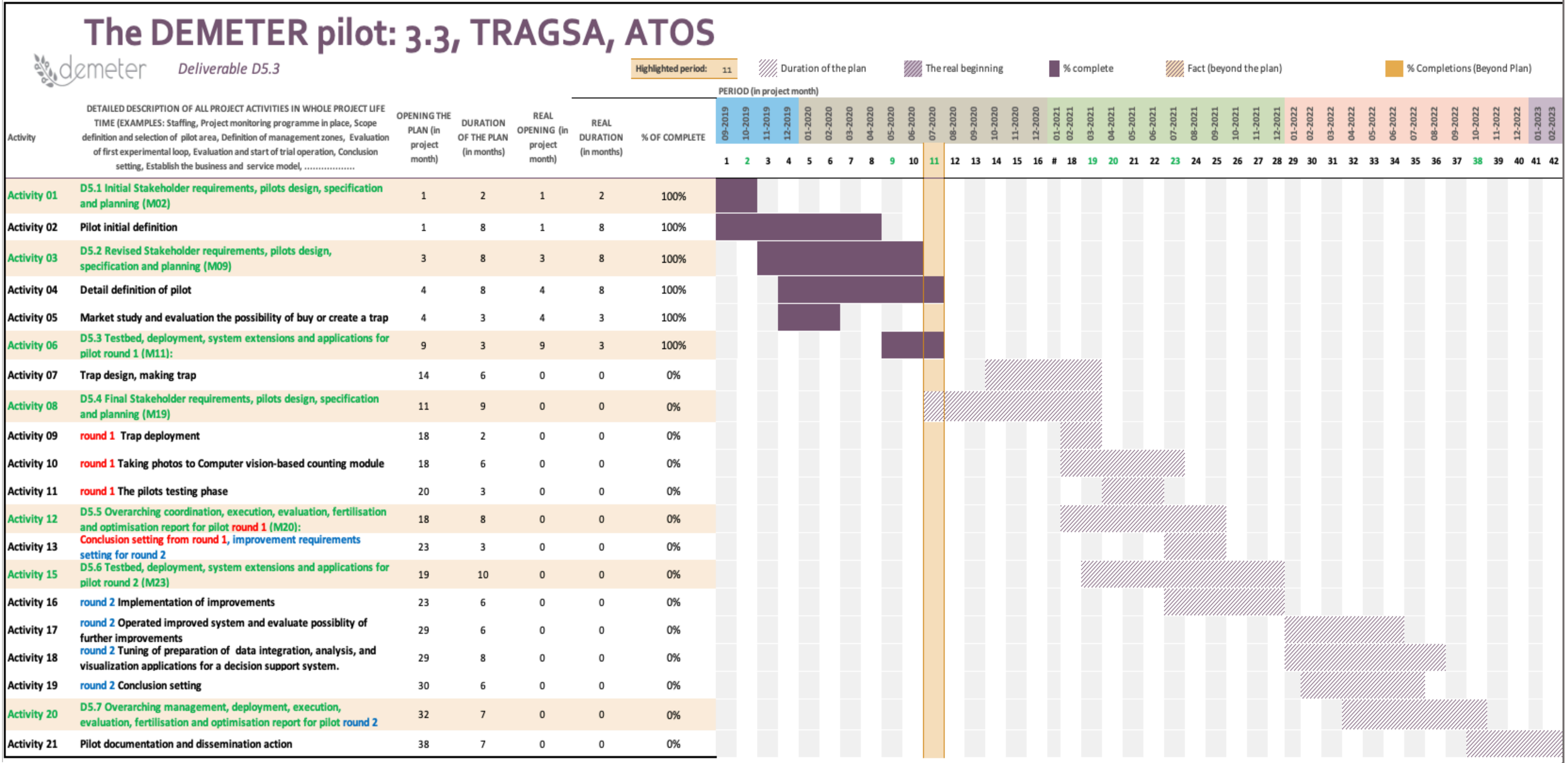
PERIOD (in project month)

set/19 out/19 nov/19 dez/19 jan/20 fev/20 mar/20 abr/20 mai/20 jun/20 jul/20 ago/20 set/20 out/20 nov/20 dez/20 jan/21 fev/21 mar/21 abr/21 mai/21 jun/21 jul/21 ago/21 set/21 out/21 nov/21 dez/21 jan/22 fev/22 mar/22 abr/22 mai/22 jun/22 jul/22 ago/22 set/22 out/22 nov/22 dez/22 jan/23 fev/23

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42

Activity	DETAILED DESCRIPTION OF ALL PROJECT ACTIVITIES IN WHOLE PROJECT LIFE TIME (EXAMPLES: Staffing, Project monitoring programme in place, Scope definition and selection of pilot area, Definition of management zones, Evaluation of first experimental loop, Evaluation and start of trial operation, Conclusion setting, Establish the business and service model, ...	OPENING THE PLAN (in project month)	DURATION OF THE PLAN (in months)	REAL OPENING (in project month)	REAL DURATION (in months)	% OF COMPLETE
Activity 01	D5.1 Initial Stakeholder requirements, pilots design, specification and planning (M02)	1	2	1	2	100%
Activity 02	Pilots selection in PT. Staffing to implement the Pilots	1	12	2	10	100%
Activity 03	D5.2 Revised Stakeholder requirements, pilots design, specification and planning (M09)	4	6	4	8	80%
Activity 04	Pilots monitoring programme in place	10	2	4	8	80%
Activity 05	D5.3 Testbed, deployment, system extensions and applications for pilot round 1 (M11):	9	3	11	8	10%
Activity 06	The Pilot assembly phase addressing the infrastructure and communication, physical preparation	11	8	11	8	20%
Activity 07	The Pilot assembly phase addressing the analysis and visualisation, physical preparation	11	6	12	8	10%
Activity 08	D5.4 Final Stakeholder requirements, pilots design, specification and planning (M19)	11	9	16	8	0%
Activity 06	round 1 Setting up experimental design with farmers	14	3	16	4	0%
Activity 07	round 1 Assigning machniery to run the field/farm experiment	14	3	16	4	0%
Activity 08	round 1 The pilots testing phase	16	4	18	6	0%
Activity 09	round 1 of data market for agricultural enterprise data that sits between the owners and operators of agricultural data Clouds and the farmer	16	5	18	8	0%
Activity 10	round 1 of preparation of data integration, analysis, and visualization applications for a decision support system.	18	3	20	5	0%
Activity 11	D5.5 Overarching coordination, execution, evaluation, fertilisation and optimisation report for pilot round 1 (M20):	13	8	20	3	0%
Activity 12	Conclusion setting from round 1, improvement requirements setting for round 2	19	3	20	3	0%
Activity 13	round 2 implementation of system improvements	19	3	20	3	0%
Activity 14	D5.6 Testbed, deployment, system extensions and applications for pilot round 2 (M23)	23	7	19	5	0%
Activity 15	round 2 The Trial operation and continuing in improving	23	7	23	7	0%
Activity 16	round 2 Tuning of data market for agricultural enterprise data that sits between the owners and operators of agricultural data Clouds and the	27	7	27	7	0%
Activity 17	round 2 Tuning of preparation of data integration, analysis, and visualization applications for a decision support system.	27	7	27	8	0%
Activity 18	round 2 Conclusion setting	32	5	27	8	0%
Activity 19	D5.7 Overarching management, deployment, execution, evaluation, fertilisation and optimisation report for pilot round 2 (M38)	32	7	32	7	0%
Activity 20	Establish the business and service model	38	7	38	7	0%

Pilot 3.3 Pest Management Control on Fruit Fly



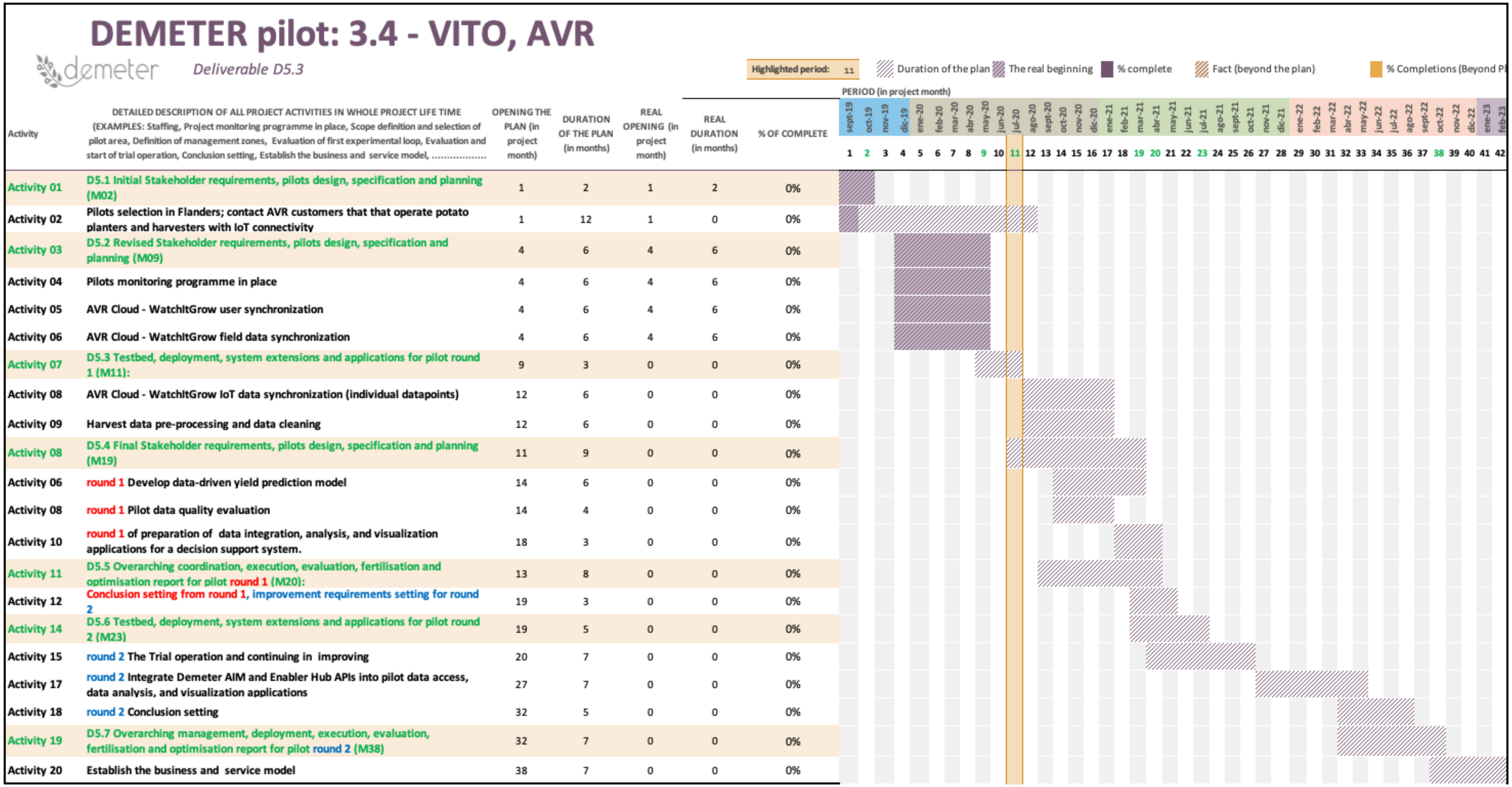
The DEMETER pilot: 3.3, TRAGSA, ATOS

Deliverable D5.3

Highlighted period: 11

Activity	DETAILED DESCRIPTION OF ALL PROJECT ACTIVITIES IN WHOLE PROJECT LIFE TIME (EXAMPLES: Staffing, Project monitoring programme in place, Scope definition and selection of pilot area, Definition of management zones, Evaluation of first experimental loop, Evaluation and start of trial operation, Conclusion setting, Establish the business and service model, ...	OPENING THE PLAN (in project month)	DURATION OF THE PLAN (in months)	REAL OPENING (in project month)	REAL DURATION (in months)	% OF COMPLETE
Activity 01	D5.1 Initial Stakeholder requirements, pilots design, specification and planning (M02)	1	2	1	2	100%
Activity 02	Pilot initial definition	1	8	1	8	100%
Activity 03	D5.2 Revised Stakeholder requirements, pilots design, specification and planning (M09)	3	8	3	8	100%
Activity 04	Detail definition of pilot	4	8	4	8	100%
Activity 05	Market study and evaluation the possibility of buy or create a trap	4	3	4	3	100%
Activity 06	D5.3 Testbed, deployment, system extensions and applications for pilot round 1 (M11):	9	3	9	3	100%
Activity 07	Trap design, making trap	14	6	0	0	0%
Activity 08	D5.4 Final Stakeholder requirements, pilots design, specification and planning (M19)	11	9	0	0	0%
Activity 09	round 1 Trap deployment	18	2	0	0	0%
Activity 10	round 1 Taking photos to Computer vision-based counting module	18	6	0	0	0%
Activity 11	round 1 The pilots testing phase	20	3	0	0	0%
Activity 12	D5.5 Overarching coordination, execution, evaluation, fertilisation and optimisation report for pilot round 1 (M20):	18	8	0	0	0%
Activity 13	Conclusion setting from round 1, improvement requirements setting for round 2	23	3	0	0	0%
Activity 15	D5.6 Testbed, deployment, system extensions and applications for pilot round 2 (M23)	19	10	0	0	0%
Activity 16	round 2 Implementation of improvements	23	6	0	0	0%
Activity 17	round 2 Operated improved system and evaluate possiblity of further improvements	29	6	0	0	0%
Activity 18	round 2 Tuning of preparation of data integration, analysis, and visualization applications for a decision support system.	29	8	0	0	0%
Activity 19	round 2 Conclusion setting	30	6	0	0	0%
Activity 20	D5.7 Overarching management, deployment, execution, evaluation, fertilisation and optimisation report for pilot round 2	32	7	0	0	0%
Activity 21	Pilot documentation and dissemination action	38	7	0	0	0%

Pilot 3.4 Open Platform for Improved Crop Monitoring in Potato Farms



DEMETER pilot: 3.4 - VITO, AVR

Deliverable D5.3

Highlighted period: 11

▨ Duration of the plan ▨ The real beginning ■ % complete ▨ Fact (beyond the plan) ■ % Completions (Beyond Pl

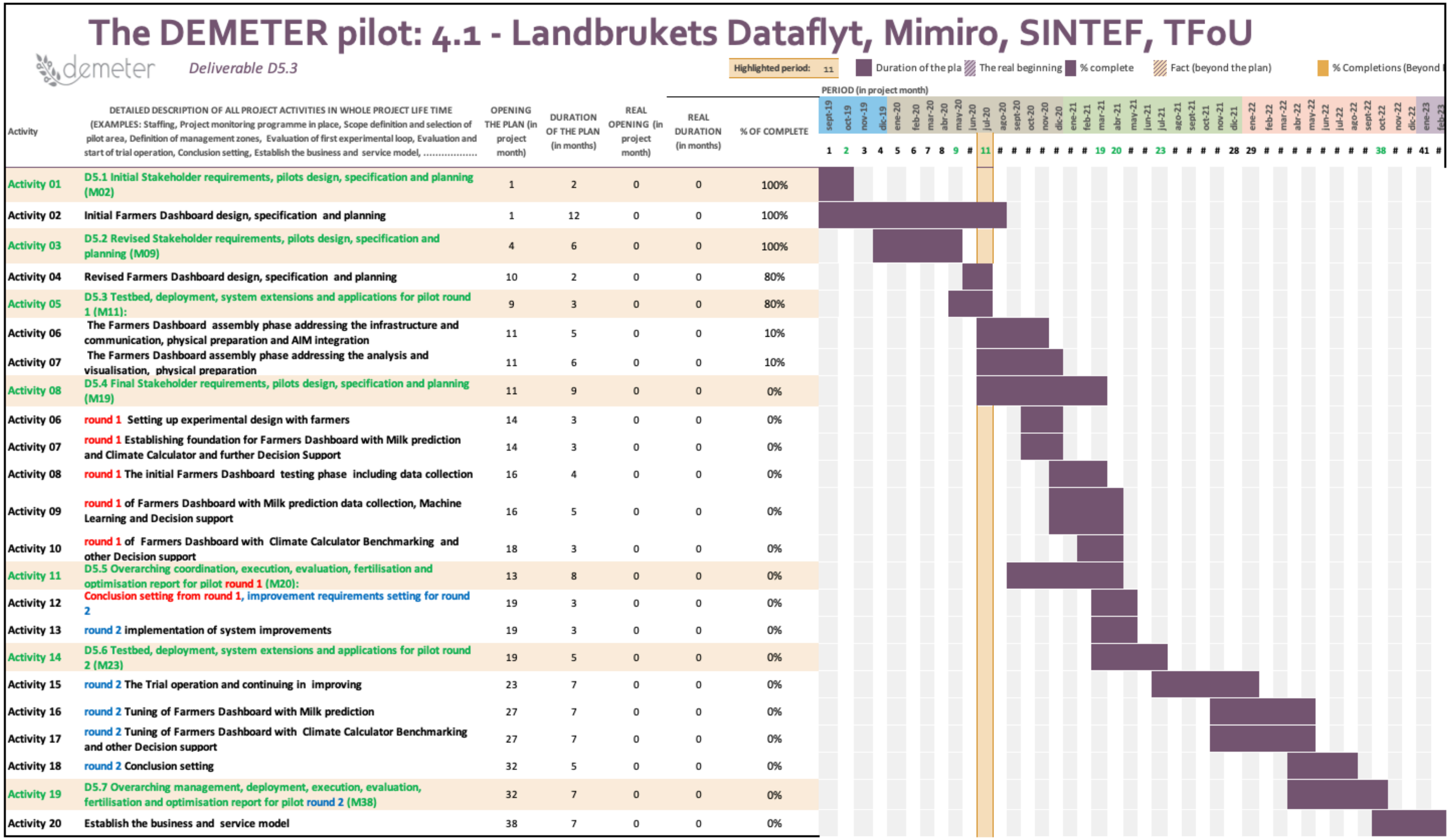
PERIOD (in project month)

sept-19 oct-19 nov-19 dic-19 ene-20 feb-20 mar-20 abr-20 may-20 jun-20 jul-20 ago-20 sept-20 oct-20 nov-20 dic-20 ene-21 feb-21 mar-21 abr-21 may-21 jun-21 jul-21 ago-21 sept-21 oct-21 nov-21 dic-21 ene-22 feb-22 mar-22 abr-22 may-22 jun-22 jul-22 ago-22 sept-22 oct-22 nov-22 dic-22 ene-23 feb-23

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42

Activity	DETAILED DESCRIPTION OF ALL PROJECT ACTIVITIES IN WHOLE PROJECT LIFE TIME (EXAMPLES: Staffing, Project monitoring programme in place, Scope definition and selection of pilot area, Definition of management zones, Evaluation of first experimental loop, Evaluation and start of trial operation, Conclusion setting, Establish the business and service model, ...	OPENING THE PLAN (in project month)	DURATION OF THE PLAN (in months)	REAL OPENING (in project month)	REAL DURATION (in months)	% OF COMPLETE
Activity 01	D5.1 Initial Stakeholder requirements, pilots design, specification and planning (M02)	1	2	1	2	0%
Activity 02	Pilots selection in Flanders; contact AVR customers that that operate potato planters and harvesters with IoT connectivity	1	12	1	0	0%
Activity 03	D5.2 Revised Stakeholder requirements, pilots design, specification and planning (M09)	4	6	4	6	0%
Activity 04	Pilots monitoring programme in place	4	6	4	6	0%
Activity 05	AVR Cloud - WatchItGrow user synchronization	4	6	4	6	0%
Activity 06	AVR Cloud - WatchItGrow field data synchronization	4	6	4	6	0%
Activity 07	D5.3 Testbed, deployment, system extensions and applications for pilot round 1 (M11):	9	3	0	0	0%
Activity 08	AVR Cloud - WatchItGrow IoT data synchronization (individual datapoints)	12	6	0	0	0%
Activity 09	Harvest data pre-processing and data cleaning	12	6	0	0	0%
Activity 08	D5.4 Final Stakeholder requirements, pilots design, specification and planning (M19)	11	9	0	0	0%
Activity 06	round 1 Develop data-driven yield prediction model	14	6	0	0	0%
Activity 08	round 1 Pilot data quality evaluation	14	4	0	0	0%
Activity 10	round 1 of preparation of data integration, analysis, and visualization applications for a decision support system.	18	3	0	0	0%
Activity 11	D5.5 Overarching coordination, execution, evaluation, fertilisation and optimisation report for pilot round 1 (M20):	13	8	0	0	0%
Activity 12	Conclusion setting from round 1, improvement requirements setting for round 2	19	3	0	0	0%
Activity 14	D5.6 Testbed, deployment, system extensions and applications for pilot round 2 (M23)	19	5	0	0	0%
Activity 15	round 2 The Trial operation and continuing in improving	20	7	0	0	0%
Activity 17	round 2 Integrate Demeter AIM and Enabler Hub APIs into pilot data access, data analysis, and visualization applications	27	7	0	0	0%
Activity 18	round 2 Conclusion setting	32	5	0	0	0%
Activity 19	D5.7 Overarching management, deployment, execution, evaluation, fertilisation and optimisation report for pilot round 2 (M38)	32	7	0	0	0%
Activity 20	Establish the business and service model	38	7	0	0	0%

Pilot 4.1 Dairy Farmers Dashboard for the Entire Milk and Meat Production Value Chain



The DEMETER pilot: 4.1 - Landbrukets Dataflyt, Mimiro, SINTEF, TFoU

Deliverable D5.3

Highlighted period: 11

Legend: ■ Duration of the pla ▨ The real beginning ■ % complete ▨ Fact (beyond the plan) ■ % Completions (Beyond

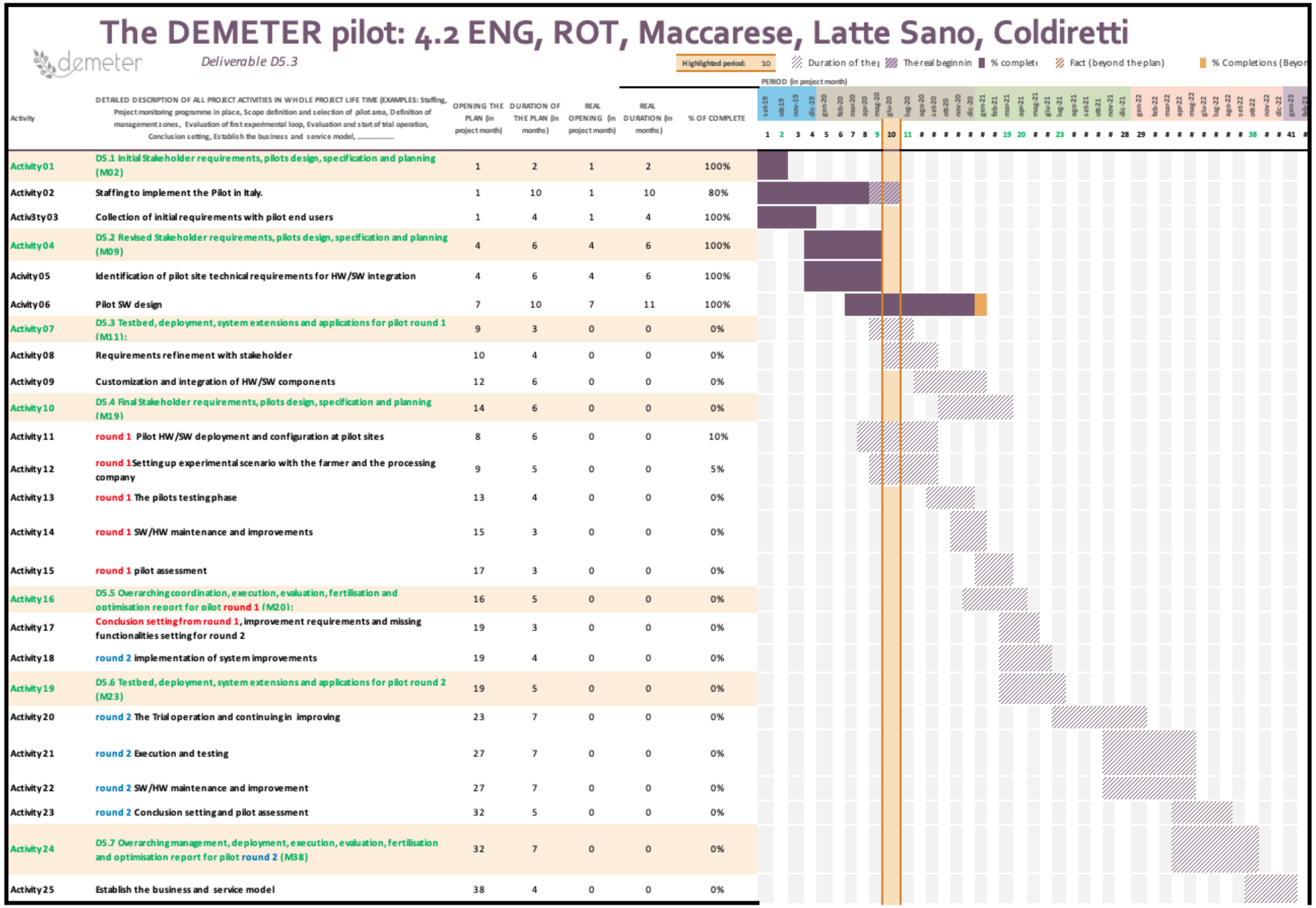
PERIOD (in project month)

sept-19 oct-19 nov-19 dic-19 ene-20 feb-20 mar-20 abr-20 may-20 jun-20 jul-20 ago-20 sept-20 oct-20 nov-20 dic-20 ene-21 feb-21 mar-21 abr-21 may-21 jun-21 jul-21 ago-21 sept-21 oct-21 nov-21 dic-21 ene-22 feb-22 mar-22 abr-22 may-22 jun-22 jul-22 ago-22 sept-22 oct-22 nov-22 dic-22 ene-23 feb-23

1 2 3 4 5 6 7 8 9 # 11 # # # # # # # 19 20 # # 23 # # # # 28 29 # # # # # # # # 38 # # 41 #

Activity	DETAILED DESCRIPTION OF ALL PROJECT ACTIVITIES IN WHOLE PROJECT LIFE TIME (EXAMPLES: Staffing, Project monitoring programme in place, Scope definition and selection of pilot area, Definition of management zones, Evaluation of first experimental loop, Evaluation and start of trial operation, Conclusion setting, Establish the business and service model, ...	OPENING THE PLAN (in project month)	DURATION OF THE PLAN (in months)	REAL OPENING (in project month)	REAL DURATION (in months)	% OF COMPLETE
Activity 01	D5.1 Initial Stakeholder requirements, pilots design, specification and planning (M02)	1	2	0	0	100%
Activity 02	Initial Farmers Dashboard design, specification and planning	1	12	0	0	100%
Activity 03	D5.2 Revised Stakeholder requirements, pilots design, specification and planning (M09)	4	6	0	0	100%
Activity 04	Revised Farmers Dashboard design, specification and planning	10	2	0	0	80%
Activity 05	D5.3 Testbed, deployment, system extensions and applications for pilot round 1 (M11):	9	3	0	0	80%
Activity 06	The Farmers Dashboard assembly phase addressing the infrastructure and communication, physical preparation and AIM integration	11	5	0	0	10%
Activity 07	The Farmers Dashboard assembly phase addressing the analysis and visualisation, physical preparation	11	6	0	0	10%
Activity 08	D5.4 Final Stakeholder requirements, pilots design, specification and planning (M19)	11	9	0	0	0%
Activity 06	round 1 Setting up experimental design with farmers	14	3	0	0	0%
Activity 07	round 1 Establishing foundation for Farmers Dashboard with Milk prediction and Climate Calculator and further Decision Support	14	3	0	0	0%
Activity 08	round 1 The initial Farmers Dashboard testing phase including data collection	16	4	0	0	0%
Activity 09	round 1 of Farmers Dashboard with Milk prediction data collection, Machine Learning and Decision support	16	5	0	0	0%
Activity 10	round 1 of Farmers Dashboard with Climate Calculator Benchmarking and other Decision support	18	3	0	0	0%
Activity 11	D5.5 Overarching coordination, execution, evaluation, fertilisation and optimisation report for pilot round 1 (M20):	13	8	0	0	0%
Activity 12	Conclusion setting from round 1, improvement requirements setting for round 2	19	3	0	0	0%
Activity 13	round 2 implementation of system improvements	19	3	0	0	0%
Activity 14	D5.6 Testbed, deployment, system extensions and applications for pilot round 2 (M23)	19	5	0	0	0%
Activity 15	round 2 The Trial operation and continuing in improving	23	7	0	0	0%
Activity 16	round 2 Tuning of Farmers Dashboard with Milk prediction	27	7	0	0	0%
Activity 17	round 2 Tuning of Farmers Dashboard with Climate Calculator Benchmarking and other Decision support	27	7	0	0	0%
Activity 18	round 2 Conclusion setting	32	5	0	0	0%
Activity 19	D5.7 Overarching management, deployment, execution, evaluation, fertilisation and optimisation report for pilot round 2 (M38)	32	7	0	0	0%
Activity 20	Establish the business and service model	38	7	0	0	0%

Pilot 4.2 Consumer Awareness: Milk Quality and Animal Welfare Tracking



The DEMETER pilot: 4.2 ENG, ROT, Maccarese, Latte Sano, Coldiretti

Deliverable D5.3

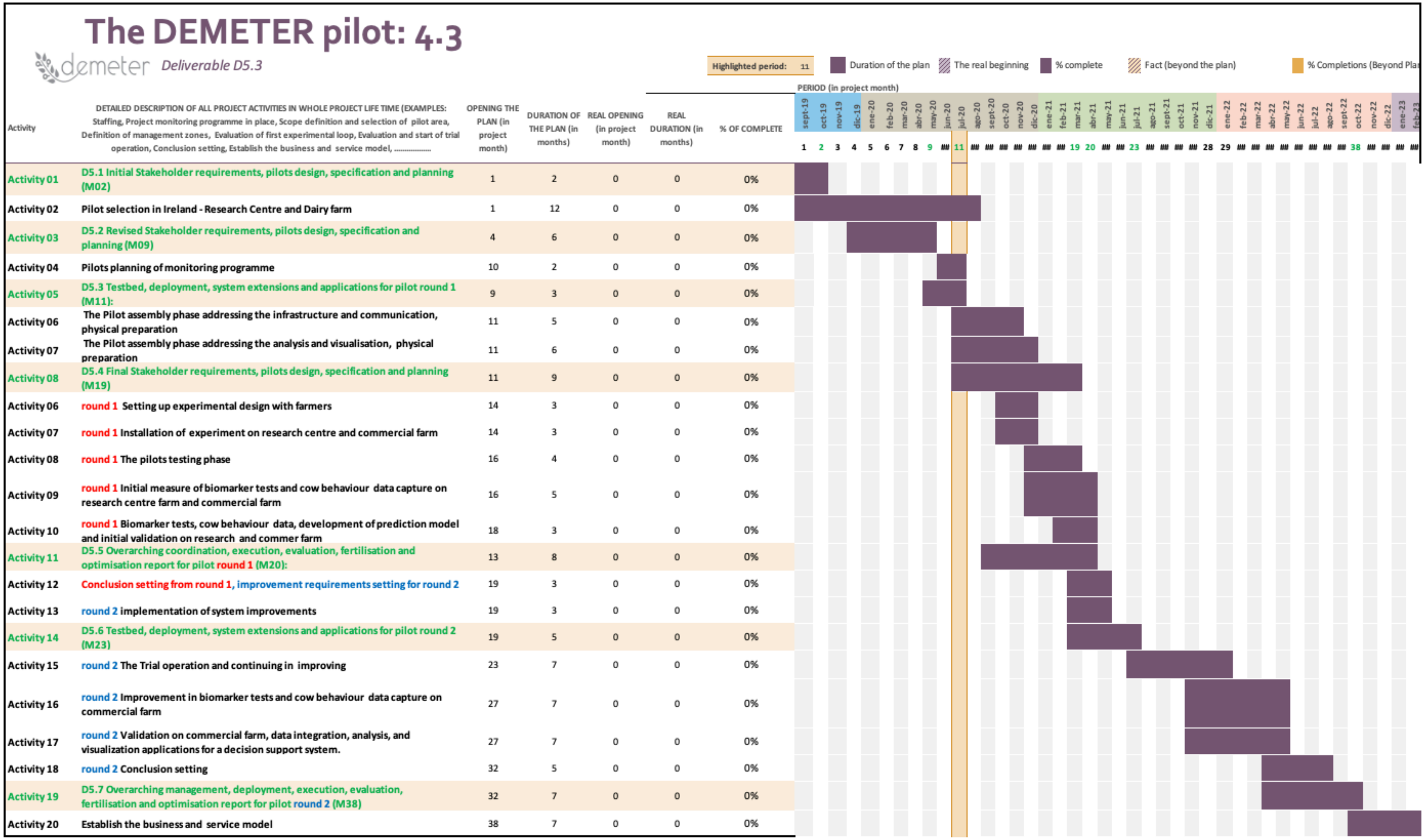
Highlighted period: 10

▨ Duration of the| ▨ The real beginnin ■ % complet| ▨ Fact (beyond the plan) ■ % Completions (Beyon

PERIOD (in project month)

Activity	DETAILED DESCRIPTION OF ALL PROJECT ACTIVITIES IN WHOLE PROJECT LIFE TIME (EXAMPLES: Staffing, Project monitoring programme in place, Scope definition and selection of pilot area, Definition of management zones, Evaluation of first experimental loop, Evaluation and start of trial operation, Conclusion setting, Establish the business and service model, ...	OPENING THE PLAN (in project month)	DURATION OF THE PLAN (in months)	REAL OPENING (in project month)	REAL DURATION (in months)	% OF COMPLETE
Activity01	D5.1 Initial Stakeholder requirements, pilots design, specification and planning (M02)	1	2	1	2	100%
Activity02	Staffing to implement the Pilot in Italy.	1	10	1	10	80%
Activ3ty03	Collection of initial requirements with pilot end users	1	4	1	4	100%
Activity04	D5.2 Revised Stakeholder requirements, pilots design, specification and planning (M09)	4	6	4	6	100%
Acivity05	Identification of pilot site technical requirements for HW/SW integration	4	6	4	6	100%
Acivity06	Pilot SW design	7	10	7	11	100%
Activity07	D5.3 Testbed, deployment, system extensions and applications for pilot round 1 (M11):	9	3	0	0	0%
Activity08	Requirements refinement with stakeholder	10	4	0	0	0%
Activity09	Customization and integration of HW/SW components	12	6	0	0	0%
Activity10	D5.4 Final Stakeholder requirements, pilots design, specification and planning (M19)	14	6	0	0	0%
Activity11	round 1 Pilot HW/SW deployment and configuration at pilot sites	8	6	0	0	10%
Activity12	round 1 Setting up experimental scenario with the farmer and the processing company	9	5	0	0	5%
Activity13	round 1 The pilots testing phase	13	4	0	0	0%
Activity14	round 1 SW/HW maintenance and improvements	15	3	0	0	0%
Activity15	round 1 pilot assessment	17	3	0	0	0%
Activity16	D5.5 Overarching coordination, execution, evaluation, fertilisation and optimisation report for pilot round 1 (M20):	16	5	0	0	0%
Activity17	Conclusion setting from round 1, improvement requirements and missing functionalities setting for round 2	19	3	0	0	0%
Activity18	round 2 implementation of system improvements	19	4	0	0	0%
Activity19	D5.6 Testbed, deployment, system extensions and applications for pilot round 2 (M23)	19	5	0	0	0%
Activity20	round 2 The Trial operation and continuing in improving	23	7	0	0	0%
Activity21	round 2 Execution and testing	27	7	0	0	0%
Activity22	round 2 SW/HW maintenance and improvement	27	7	0	0	0%
Activity23	round 2 Conclusion setting and pilot assessment	32	5	0	0	0%
Activity24	D5.7 Overarching management, deployment, execution, evaluation, fertilisation and optimisation report for pilot round 2 (M38)	32	7	0	0	0%
Activity25	Establish the business and service model	38	4	0	0	0%

Pilot 4.3 Proactive Milk Quality Control



The DEMETER pilot: 4.3

Deliverable D5.3

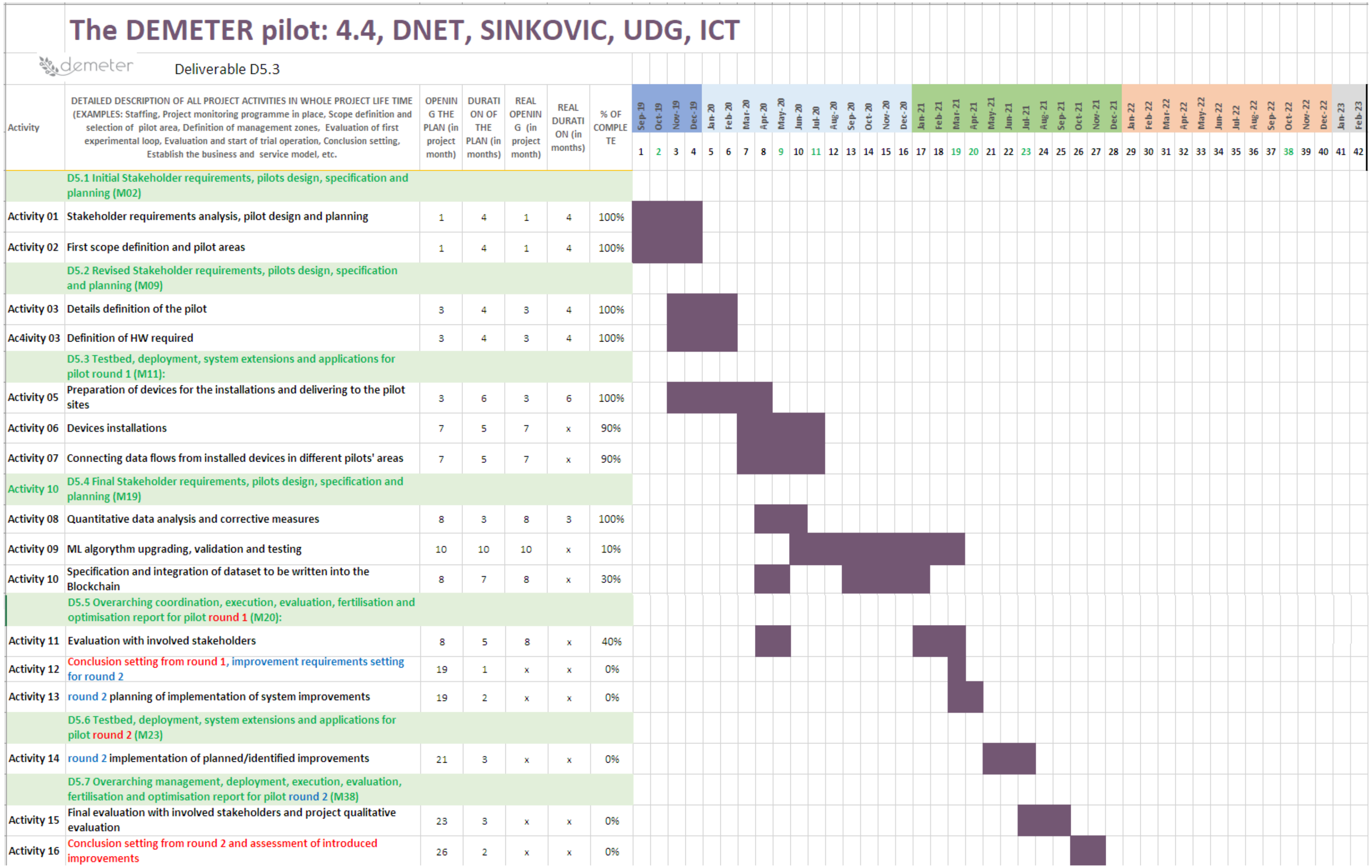
Highlighted period: 11

■ Duration of the plan ▨ The real beginning ■ % complete ▨ Fact (beyond the plan) ■ % Completions (Beyond Pla

PERIOD (in project month)

Activity	DETAILED DESCRIPTION OF ALL PROJECT ACTIVITIES IN WHOLE PROJECT LIFE TIME (EXAMPLES: Staffing, Project monitoring programme in place, Scope definition and selection of pilot area, Definition of management zones, Evaluation of first experimental loop, Evaluation and start of trial operation, Conclusion setting, Establish the business and service model, ...	OPENING THE PLAN (in project month)	DURATION OF THE PLAN (in months)	REAL OPENING (in project month)	REAL DURATION (in months)	% OF COMPLETE
Activity 01	D5.1 Initial Stakeholder requirements, pilots design, specification and planning (M02)	1	2	0	0	0%
Activity 02	Pilot selection in Ireland - Research Centre and Dairy farm	1	12	0	0	0%
Activity 03	D5.2 Revised Stakeholder requirements, pilots design, specification and planning (M09)	4	6	0	0	0%
Activity 04	Pilots planning of monitoring programme	10	2	0	0	0%
Activity 05	D5.3 Testbed, deployment, system extensions and applications for pilot round 1 (M11):	9	3	0	0	0%
Activity 06	The Pilot assembly phase addressing the infrastructure and communication, physical preparation	11	5	0	0	0%
Activity 07	The Pilot assembly phase addressing the analysis and visualisation, physical preparation	11	6	0	0	0%
Activity 08	D5.4 Final Stakeholder requirements, pilots design, specification and planning (M19)	11	9	0	0	0%
Activity 06	round 1 Setting up experimental design with farmers	14	3	0	0	0%
Activity 07	round 1 Installation of experiment on research centre and commercial farm	14	3	0	0	0%
Activity 08	round 1 The pilots testing phase	16	4	0	0	0%
Activity 09	round 1 Initial measure of biomarker tests and cow behaviour data capture on research centre farm and commercial farm	16	5	0	0	0%
Activity 10	round 1 Biomarker tests, cow behaviour data, development of prediction model and initial validation on research and commer farm	18	3	0	0	0%
Activity 11	D5.5 Overarching coordination, execution, evaluation, fertilisation and optimisation report for pilot round 1 (M20):	13	8	0	0	0%
Activity 12	Conclusion setting from round 1, improvement requirements setting for round 2	19	3	0	0	0%
Activity 13	round 2 implementation of system improvements	19	3	0	0	0%
Activity 14	D5.6 Testbed, deployment, system extensions and applications for pilot round 2 (M23)	19	5	0	0	0%
Activity 15	round 2 The Trial operation and continuing in improving	23	7	0	0	0%
Activity 16	round 2 Improvement in biomarker tests and cow behaviour data capture on commercial farm	27	7	0	0	0%
Activity 17	round 2 Validation on commercial farm, data integration, analysis, and visualization applications for a decision support system.	27	7	0	0	0%
Activity 18	round 2 Conclusion setting	32	5	0	0	0%
Activity 19	D5.7 Overarching management, deployment, execution, evaluation, fertilisation and optimisation report for pilot round 2 (M38)	32	7	0	0	0%
Activity 20	Establish the business and service model	38	7	0	0	0%

Pilot 4.4 Optimal Chicken Farm Management

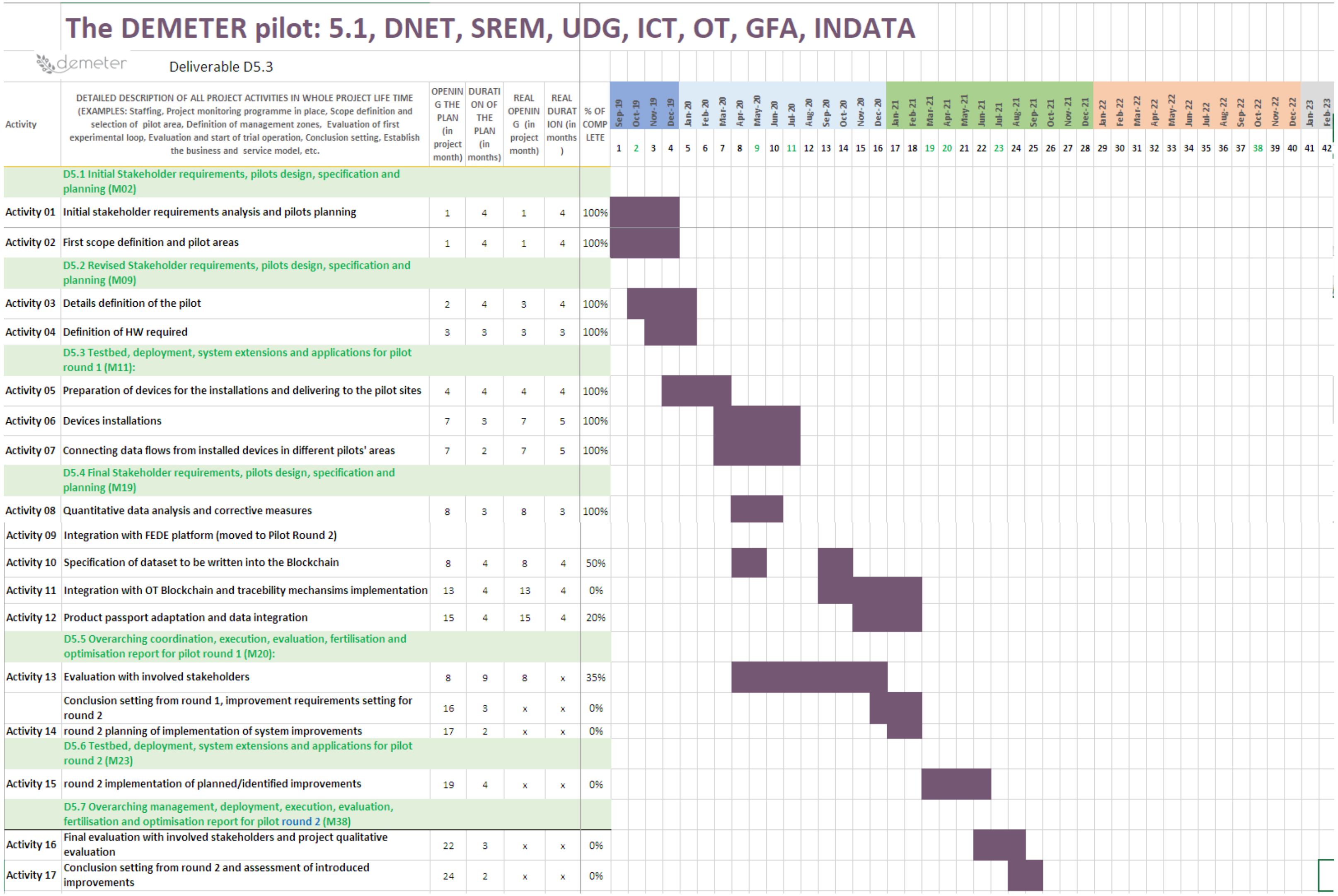


The DEMETER pilot: 4.4, DNET, SINKOVIC, UDG, ICT

demeter Deliverable D5.3

Activity	DETAILED DESCRIPTION OF ALL PROJECT ACTIVITIES IN WHOLE PROJECT LIFE TIME (EXAMPLES: Staffing, Project monitoring programme in place, Scope definition and selection of pilot area, Definition of management zones, Evaluation of first experimental loop, Evaluation and start of trial operation, Conclusion setting, Establish the business and service model, etc.	OPENING THE PLAN (in project month)	DURATION OF THE PLAN (in months)	REAL OPENING (in project month)	REAL DURATION (in months)	% OF COMPLETE	Sep-19	Oct-19	Nov-19	Dec-19	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20	Jan-21	Feb-21	Mar-21	Apr-21	May-21	Jun-21	Jul-21	Aug-21	Sep-21	Oct-21	Nov-21	Dec-21	Jan-22	Feb-22	Mar-22	Apr-22	May-22	Jun-22	Jul-22	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22	Jan-23	Feb-23
							1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
	D5.1 Initial Stakeholder requirements, pilots design, specification and planning (M02)																																																
Activity 01	Stakeholder requirements analysis, pilot design and planning	1	4	1	4	100%	▨	▨	▨	▨																																							
Activity 02	First scope definition and pilot areas	1	4	1	4	100%	▨	▨	▨	▨																																							
	D5.2 Revised Stakeholder requirements, pilots design, specification and planning (M09)																																																
Activity 03	Details definition of the pilot	3	4	3	4	100%			▨	▨	▨	▨																																					
Ac4ivity 03	Definition of HW required	3	4	3	4	100%			▨	▨	▨	▨																																					
	D5.3 Testbed, deployment, system extensions and applications for pilot round 1 (M11):																																																
Activity 05	Preparation of devices for the installations and delivering to the pilot sites	3	6	3	6	100%			▨	▨	▨	▨	▨	▨																																			
Activity 06	Devices installations	7	5	7	x	90%							▨	▨	▨	▨	▨																																
Activity 07	Connecting data flows from installed devices in different pilots' areas	7	5	7	x	90%							▨	▨	▨	▨	▨																																
Activity 10	D5.4 Final Stakeholder requirements, pilots design, specification and planning (M19)																																																
Activity 08	Quantitative data analysis and corrective measures	8	3	8	3	100%								▨	▨	▨																																	
Activity 09	ML algorythm upgrading, validation and testing	10	10	10	x	10%										▨	▨	▨	▨	▨	▨	▨	▨	▨	▨																							
Activity 10	Specification and integration of dataset to be written into the Blockchain	8	7	8	x	30%								▨	▨				▨	▨	▨	▨	▨																									
	D5.5 Overarching coordination, execution, evaluation, fertilisation and optimisation report for pilot round 1 (M20):																																																
Activity 11	Evaluation with involved stakeholders	8	5	8	x	40%								▨	▨								▨	▨	▨																							
Activity 12	Conclusion setting from round 1, improvement requirements setting for round 2	19	1	x	x	0%																			▨																							
Activity 13	round 2 planning of implementation of system improvements	19	2	x	x	0%																			▨	▨																						
	D5.6 Testbed, deployment, system extensions and applications for pilot round 2 (M23)																																																
Activity 14	round 2 implementation of planned/identified improvements	21	3	x	x	0%																					▨	▨	▨																			
	D5.7 Overarching management, deployment, execution, evaluation, fertilisation and optimisation report for pilot round 2 (M38)																																																
Activity 15	Final evaluation with involved stakeholders and project qualitative evaluation	23	3	x	x	0%																							▨	▨	▨																	
Activity 16	Conclusion setting from round 2 and assessment of introduced improvements	26	2	x	x	0%																										▨	▨															

Pilot 5.1 Disease Prediction and Supply Chain Transparency for Orchards/Vineyards



The DEMETER pilot: 5.1, DNET, SREM, UDG, ICT, OT, GFA, INDATA

Deliverable D5.3

Activity	DETAILED DESCRIPTION OF ALL PROJECT ACTIVITIES IN WHOLE PROJECT LIFE TIME (EXAMPLES: Staffing, Project monitoring programme in place, Scope definition and selection of pilot area, Definition of management zones, Evaluation of first experimental loop, Evaluation and start of trial operation, Conclusion setting, Establish the business and service model, etc.	OPENING THE PLAN (in project month)	DURATION OF THE PLAN (in months)	REAL OPENING (in project month)	REAL DURATION (in months)	% OF COMPLETE
	D5.1 Initial Stakeholder requirements, pilots design, specification and planning (M02)					
Activity 01	Initial stakeholder requirements analysis and pilots planning	1	4	1	4	100%
Activity 02	First scope definition and pilot areas	1	4	1	4	100%
	D5.2 Revised Stakeholder requirements, pilots design, specification and planning (M09)					
Activity 03	Details definition of the pilot	2	4	3	4	100%
Activity 04	Definition of HW required	3	3	3	3	100%
	D5.3 Testbed, deployment, system extensions and applications for pilot round 1 (M11):					
Activity 05	Preparation of devices for the installations and delivering to the pilot sites	4	4	4	4	100%
Activity 06	Devices installations	7	3	7	5	100%
Activity 07	Connecting data flows from installed devices in different pilots' areas	7	2	7	5	100%
	D5.4 Final Stakeholder requirements, pilots design, specification and planning (M19)					
Activity 08	Quantitative data analysis and corrective measures	8	3	8	3	100%
Activity 09	Integration with FEDE platform (moved to Pilot Round 2)					
Activity 10	Specification of dataset to be written into the Blockchain	8	4	8	4	50%
Activity 11	Integration with OT Blockchain and tracebility mechansims implementation	13	4	13	4	0%
Activity 12	Product passport adaptation and data integration	15	4	15	4	20%
	D5.5 Overarching coordination, execution, evaluation, fertilisation and optimisation report for pilot round 1 (M20):					
Activity 13	Evaluation with involved stakeholders	8	9	8	x	35%
	Conclusion setting from round 1, improvement requirements setting for round 2	16	3	x	x	0%
Activity 14	round 2 planning of implementation of system improvements	17	2	x	x	0%
	D5.6 Testbed, deployment, system extensions and applications for pilot round 2 (M23)					
Activity 15	round 2 implementation of planned/identified improvements	19	4	x	x	0%
	D5.7 Overarching management, deployment, execution, evaluation, fertilisation and optimisation report for pilot round 2 (M38)					
Activity 16	Final evaluation with involved stakeholders and project qualitative evaluation	22	3	x	x	0%
Activity 17	Conclusion setting from round 2 and assessment of introduced improvements	24	2	x	x	0%

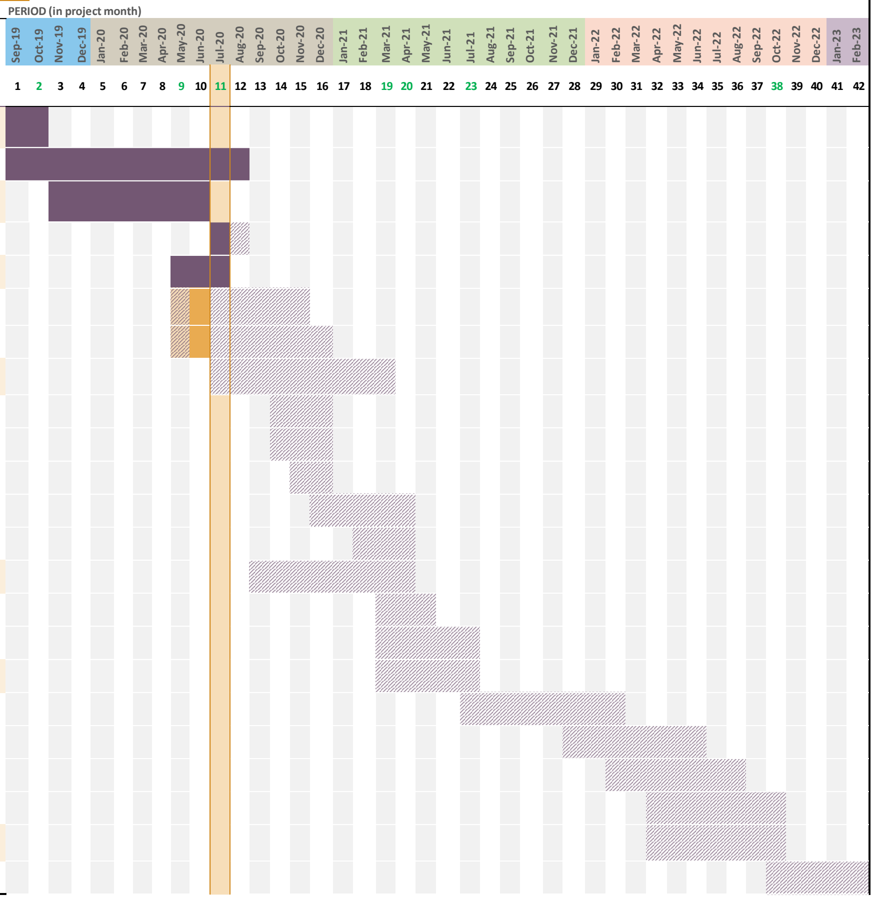
Pilot 5.2 Farm of Things in Extensive Cattle Holdings

Pilot 5.2: UPM, Centria, Tragsa, Tecnalia, Probot, Codan

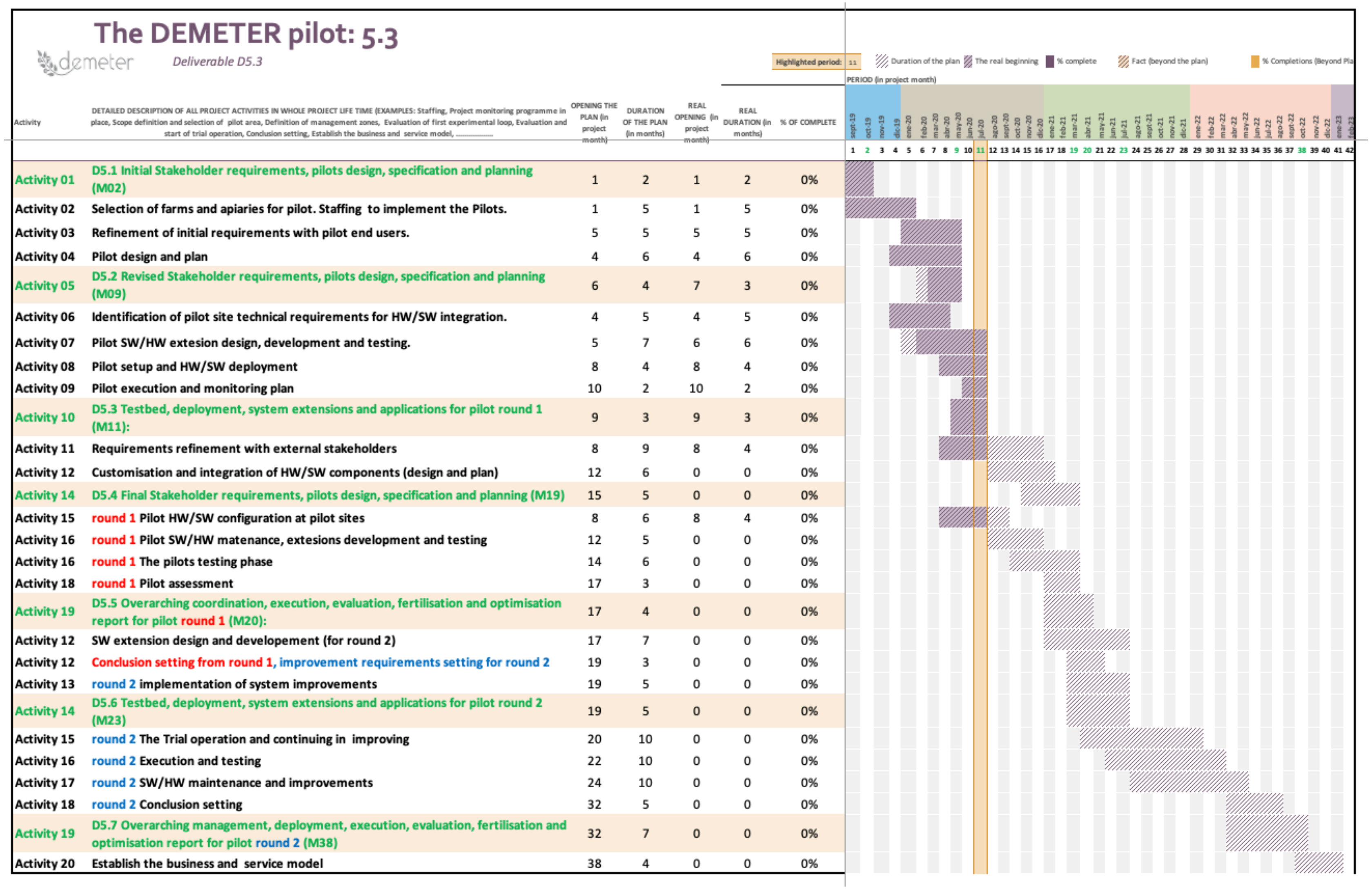
Deliverable D5.3

Highlighted period: 11 ▨ Duration of the plan ▨ The real beginning ■ % complete ▨ Fact (beyond the plan) ■ % Completions (Beyond Plan)

Activity	DETAILED DESCRIPTION OF ALL PROJECT ACTIVITIES IN WHOLE PROJECT LIFE TIME (EXAMPLES: Staffing, Project monitoring programme in place, Scope definition and selection of pilot area, Definition of management zones, Evaluation of first experimental loop, Evaluation and start of trial operation, Conclusion setting, Establish the business and service model, ...	OPENING THE PLAN (in project month)	DURATION OF THE PLAN (in months)	REAL OPENING (in project month)	REAL DURATION (in months)	% OF COMPLETE
Activity 01	D5.1 Initial Stakeholder requirements, pilots design, specification and planning (M02)	1	2	1	2	100%
Activity 02	Pilots selection in Spain and Finland. Staffing to implement the Pilots	1	12	1	12	100%
Activity 03	D5.2 Revised Stakeholder requirements, pilots design, specification and planning (M09)	3	8	3	8	100%
Activity 04	Pilots monitoring programme in place	11	2	11	1	50%
Activity 05	D5.3 Testbed, deployment, system extensions and applications for pilot round 1 (M11):	9	3	9	3	100%
Activity 06	The Pilot assembly phase addressing the infrastructure and communication, physical preparation	11	5	10	0	20%
Activity 07	The Pilot assembly phase addressing the analysis and visualisation, physical preparation	11	6	10	0	20%
Activity 08	D5.4 Final Stakeholder requirements, pilots design, specification and planning (M19)	11	9	0	0	0%
Activity 09	round 1 Setting up experimental design with farmers and producers	14	3	0	0	0%
Activity 10	round 1 Assigning machinery to run the field experiment	14	3	0	0	0%
Activity 11	round 1 Definition of consumer workshops or user feedback models	15	2	0	0	0%
Activity 12	round 1 The pilots testing phase	16	5	0	0	0%
Activity 13	round 1 of data acquisition, analysis, and visualization	18	3	0	0	0%
Activity 14	D5.5 Overarching coordination, execution, evaluation, fertilisation and optimisation report for pilot round 1 (M20):	13	8	0	0	0%
Activity 15	Conclusion setting from round 1, improvement requirements setting for round 2	19	3	0	0	0%
Activity 16	round 2 implementation of system improvements	19	5	0	0	0%
Activity 17	D5.6 Testbed, deployment, system extensions and applications for pilot round 2 (M23)	19	5	0	0	0%
Activity 18	round 2 Setting up experimental design with farmers and producers	23	8	0	0	0%
Activity 19	round 2 The pilots testing phase	28	7	0	0	0%
Activity 20	round 2 of data acquisition, analysis, and visualization	30	7	0	0	0%
Activity 21	round 2 Conclusion setting	32	7	0	0	0%
Activity 22	D5.7 Overarching management, deployment, execution, evaluation, fertilisation and optimisation report for pilot round 2 (M38)	32	7	0	0	0%
Activity 23	Establish the business and service model	38	7	0	0	0%



Pilot 5.3 Pollination Optimisation in Apiculture



The DEMETER pilot: 5.3

Deliverable D5.3

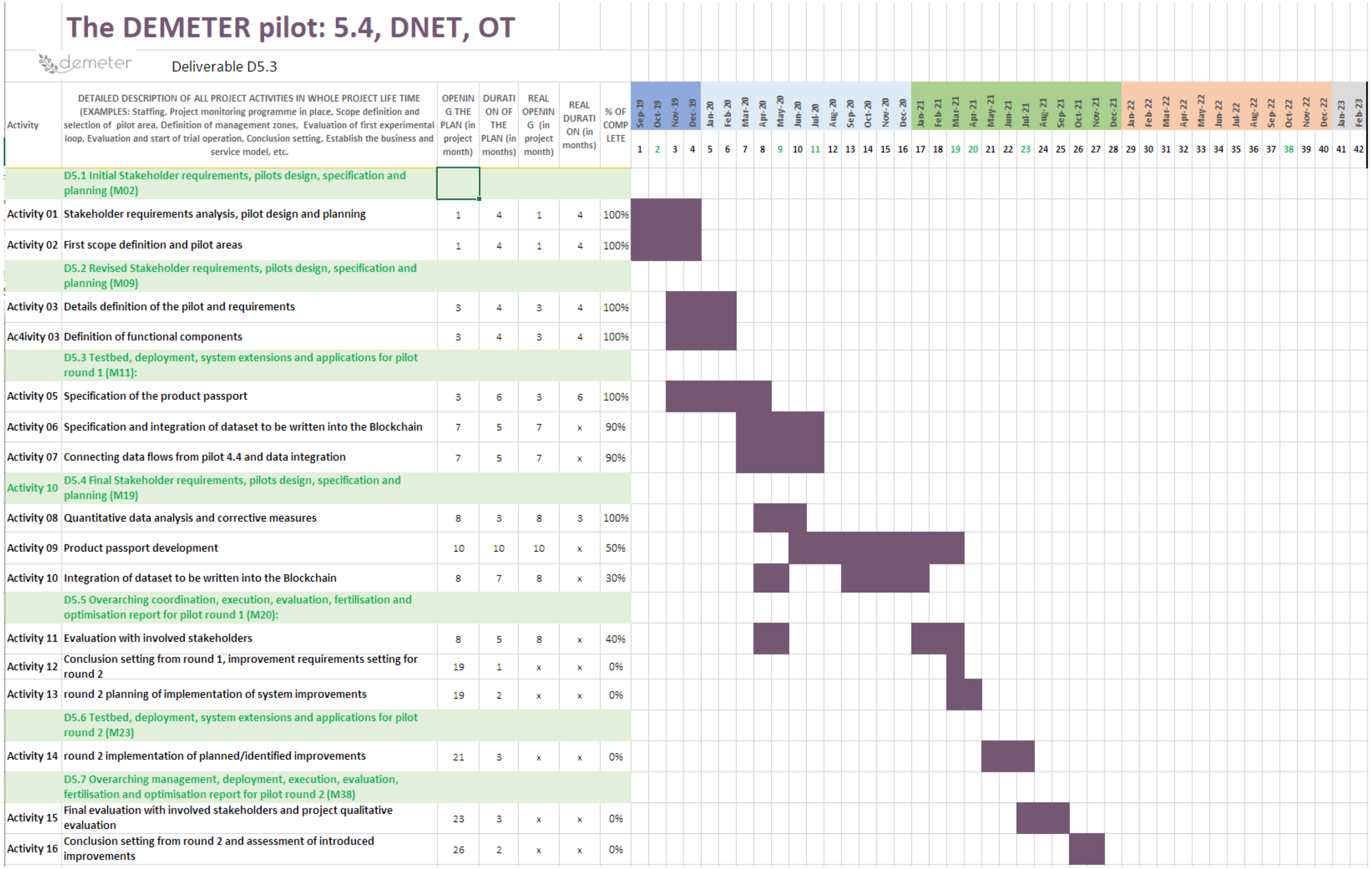
Highlighted period: 11

▨ Duration of the plan ▨ The real beginning ■ % complete ▨ Fact (beyond the plan) ■ % Completions (Beyond Pla

PERIOD (in project month)

Activity	DETAILED DESCRIPTION OF ALL PROJECT ACTIVITIES IN WHOLE PROJECT LIFE TIME (EXAMPLES: Staffing, Project monitoring programme in place, Scope definition and selection of pilot area, Definition of management zones, Evaluation of first experimental loop, Evaluation and start of trial operation, Conclusion setting, Establish the business and service model, ...	OPENING THE PLAN (in project month)	DURATION OF THE PLAN (in months)	REAL OPENING (in project month)	REAL DURATION (in months)	% OF COMPLETE
Activity 01	D5.1 Initial Stakeholder requirements, pilots design, specification and planning (M02)	1	2	1	2	0%
Activity 02	Selection of farms and apiaries for pilot. Staffing to implement the Pilots.	1	5	1	5	0%
Activity 03	Refinement of initial requirements with pilot end users.	5	5	5	5	0%
Activity 04	Pilot design and plan	4	6	4	6	0%
Activity 05	D5.2 Revised Stakeholder requirements, pilots design, specification and planning (M09)	6	4	7	3	0%
Activity 06	Identification of pilot site technical requirements for HW/SW integration.	4	5	4	5	0%
Activity 07	Pilot SW/HW extesion design, development and testing.	5	7	6	6	0%
Activity 08	Pilot setup and HW/SW deployment	8	4	8	4	0%
Activity 09	Pilot execution and monitoring plan	10	2	10	2	0%
Activity 10	D5.3 Testbed, deployment, system extensions and applications for pilot round 1 (M11):	9	3	9	3	0%
Activity 11	Requirements refinement with external stakeholders	8	9	8	4	0%
Activity 12	Customisation and integration of HW/SW components (design and plan)	12	6	0	0	0%
Activity 14	D5.4 Final Stakeholder requirements, pilots design, specification and planning (M19)	15	5	0	0	0%
Activity 15	round 1 Pilot HW/SW configuration at pilot sites	8	6	8	4	0%
Activity 16	round 1 Pilot SW/HW matenance, extesions development and testing	12	5	0	0	0%
Activity 16	round 1 The pilots testing phase	14	6	0	0	0%
Activity 18	round 1 Pilot assessment	17	3	0	0	0%
Activity 19	D5.5 Overarching coordination, execution, evaluation, fertilisation and optimisation report for pilot round 1 (M20):	17	4	0	0	0%
Activity 12	SW extension design and developement (for round 2)	17	7	0	0	0%
Activity 12	Conclusion setting from round 1, improvement requirements setting for round 2	19	3	0	0	0%
Activity 13	round 2 implementation of system improvements	19	5	0	0	0%
Activity 14	D5.6 Testbed, deployment, system extensions and applications for pilot round 2 (M23)	19	5	0	0	0%
Activity 15	round 2 The Trial operation and continuing in improving	20	10	0	0	0%
Activity 16	round 2 Execution and testing	22	10	0	0	0%
Activity 17	round 2 SW/HW maintenance and improvements	24	10	0	0	0%
Activity 18	round 2 Conclusion setting	32	5	0	0	0%
Activity 19	D5.7 Overarching management, deployment, execution, evaluation, fertilisation and optimisation report for pilot round 2 (M38)	32	7	0	0	0%
Activity 20	Establish the business and service model	38	4	0	0	0%

Pilot 5.4 Transparent Supply Chain in Poultry Industry



The DEMETER pilot: 5.4, DNET, OT

Deliverable D5.3

Activity	DETAILED DESCRIPTION OF ALL PROJECT ACTIVITIES IN WHOLE PROJECT LIFE TIME (EXAMPLES: Staffing, Project monitoring programme in place, Scope definition and selection of pilot area, Definition of management zones, Evaluation of first experimental loop, Evaluation and start of trial operation, Conclusion setting, Establish the business and service model, etc.	OPENING THE PLAN (in project month)	DURATION OF THE PLAN (in months)	REAL OPENING (in project month)	REAL DURATION (in months)	% OF COMPLETE	Sep-19 1	Oct-19 2	Nov-19 3	Dec-19 4	Jan-20 5	Feb-20 6	Mar-20 7	Apr-20 8	May-20 9	Jun-20 10	Jul-20 11	Aug-20 12	Sep-20 13	Oct-20 14	Nov-20 15	Dec-20 16	Jan-21 17	Feb-21 18	Mar-21 19	Apr-21 20	May-21 21	Jun-21 22	Jul-21 23	Aug-21 24	Sep-21 25	Oct-21 26	Nov-21 27	Dec-21 28	Jan-22 29	Feb-22 30	Mar-22 31	Apr-22 32	May-22 33	Jun-22 34	Jul-22 35	Aug-22 36	Sep-22 37	Oct-22 38	Nov-22 39	Dec-22 40	Jan-23 41	Feb-23 42
	D5.1 Initial Stakeholder requirements, pilots design, specification and planning (M02)																																																
Activity 01	Stakeholder requirements analysis, pilot design and planning	1	4	1	4	100%	▨	▨	▨	▨																																						
Activity 02	First scope definition and pilot areas	1	4	1	4	100%	▨	▨	▨	▨																																						
	D5.2 Revised Stakeholder requirements, pilots design, specification and planning (M09)																																																
Activity 03	Details definition of the pilot and requirements	3	4	3	4	100%			▨	▨	▨	▨																																				
Ac4ivity 03	Definition of functional components	3	4	3	4	100%			▨	▨	▨	▨																																				
	D5.3 Testbed, deployment, system extensions and applications for pilot round 1 (M11):																																																
Activity 05	Specification of the product passport	3	6	3	6	100%			▨	▨	▨	▨	▨	▨																																		
Activity 06	Specification and integration of dataset to be written into the Blockchain	7	5	7	x	90%							▨	▨	▨	▨	▨																															
Activity 07	Connecting data flows from pilot 4.4 and data integration	7	5	7	x	90%							▨	▨	▨	▨	▨																															
Activity 10	D5.4 Final Stakeholder requirements, pilots design, specification and planning (M19)																																																
Activity 08	Quantitative data analysis and corrective measures	8	3	8	3	100%								▨	▨	▨																																
Activity 09	Product passport development	10	10	10	x	50%										▨	▨	▨	▨	▨	▨	▨	▨	▨	▨																							
Activity 10	Integration of dataset to be written into the Blockchain	8	7	8	x	30%								▨	▨				▨	▨	▨	▨	▨																									
	D5.5 Overarching coordination, execution, evaluation, fertilisation and optimisation report for pilot round 1 (M20):																																																
Activity 11	Evaluation with involved stakeholders	8	5	8	x	40%								▨	▨								▨	▨	▨																							
Activity 12	Conclusion setting from round 1, improvement requirements setting for round 2	19	1	x	x	0%																			▨																							
Activity 13	round 2 planning of implementation of system improvements	19	2	x	x	0%																			▨	▨																						
	D5.6 Testbed, deployment, system extensions and applications for pilot round 2 (M23)																																																
Activity 14	round 2 implementation of planned/identified improvements	21	3	x	x	0%																					▨	▨	▨																			
	D5.7 Overarching management, deployment, execution, evaluation, fertilisation and optimisation report for pilot round 2 (M38)																																																
Activity 15	Final evaluation with involved stakeholders and project qualitative evaluation	23	3	x	x	0%																							▨	▨	▨																	
Activity 16	Conclusion setting from round 2 and assessment of introduced improvements	26	2	x	x	0%																										▨	▨															

Annex 5 – DEMETER components adopted in the first pilot round - pilot mapping table

WP2 pilot mapping table

Table 27: WP2 pilot mapping table

Core/Advanced Enablers	Id	Name	Pilots																		
			1.1 & 1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4	5.1	5.2	5.3	5.4
Core Enablers	2.A.1	Agriculture Information Model (AIM)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	2.A.2	Semantic Mappings to AIM	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	2.D	Data Security & Privacy	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Advanced Enablers	2.B.1	Data management	X					X			X				X				X		
	2.B.2	Data preparation & integration					X	X	X			X		X							
	2.C.1	Data quality				X	X		X												
	2.C.2	Targeted Data Fusion	X	X		(X)				X	X	X	X	X		X	X	X	(X)	X	X
	2.C.3	Targeted Data Analytics	X	X		X				X	X	X	X	X	X	X	X	X	(X)	X	X
	2.C.4	Machine Learning Analytics	X	X		(X)				(X)		(X)	(X)		(X)	(X)	(X)	(X)	(X)		

WP3 pilot mapping table

Table 28: WP3 pilot mapping table

Core Enabler/ Cloud Component	Id	Name	Pilots																		
			1.1 & 1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4	5.1	5.2	5.3	5.4
Cloud Component	3.B.1	Brokerage Service Environment	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Core Enabler	3.B.2	Functional Interoperability Core Enabler	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Cloud Component	3.D.1	Access Control Server	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Core Enabler	3.D.2	Security Core Enabler	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Core Enabler	3.D.3	Communication & Networking Core Enabler	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Cloud Component	3.E.1	DEMETER Enabler Hub	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Core Enabler	3.E.2	DEH Client Core Enabler	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

WP4 pilot mapping table

Table 29: WP4 pilot mapping table

Specific components/ Generic components	**Id**	**Name**	**Pilots**																		
			1.1 & 1.2	**1.3**	**1.4**	**2.1**	**2.2**	**2.3**	**2.4**	**3.1**	**3.2**	**3.3**	**3.4**	**4.1**	**4.2**	**4.3**	**4.4**	**5.1**	**5.2**	**5.3**	**5.4**
Specific components	4.A.1	Plant Yield Estimation	X	X	X								X								
	4.A.2	Plant Phenology Estimation								X											
	4.A.3	Plant Stress Detection			X																
	4.A.4	Detect Crop Type											X								
	4.A.5	Estimate Beehive																		X	
	4.B.1	Crop-soil featuring	X	X						X	X										
	4.B.2	Water Balance featuring	X	X						X	X										
	4.C.1	Nitrogen Balance Model		T	X			X		T	X										
	4.C.2	Nutrient Monitor		T	X			X		T	X										
	4.D.1	Emission				X															
	4.D.2	Field Operation						X										X	X		
	4.D.3	Variable Rate											X					X	X		
	4.E.1	Computer vision-based counting module	X									X						X		X	
	4.E.2	Estimate temperature-related pest events								X		X									
	4.F.1	Estimate Milk Production												X	X		X				X
	4.F.2	Poultry Feeding															X				X
	4.G.1	Estimate Animal Welfare Condition													X	X	X				X
	4.G.2	Stress Recognition: Support Vector Machine for Poultry Stress detection															X				X
Generic components	4.H.1	Traceability													X						
	4.H.2	Transport Condition																X			X
	4.H.3	Field Book and FaST	X	X	X	X	X	X	X	X	X	X	X								
	4.I.0	Indicator Engine for Benchmarking Purpose	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	4.I.1	Generic Farm Comparison	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	4.I.2	Neighbour benchmarking							X	X				X	X						
	4.I.3	Technology benchmarking	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X