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Testbed Deployment, System Extensions and Applications for Pilot Round 1

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SUMMARY

DEMETER involves 60 partners distributed across 18 European countries where 20 experimental pilots have been planned with the idea of overcoming specific challenges that each of the aforementioned pilots face. Given the high number of pilots, they have been grouped into 5 thematic clusters:

- Arable Crops: Water and Energy Management
- Arable Crops: Agricultural Machinery, Precision Farming
- Fruits and Vegetables: Healthy and High-Quality Crops
- Livestock: Animal Health, High Quality and Optimal Management of Animal Products
- Cross-Sectorial: Full Supply Chain, Interoperability, Robotics

These pilots have been cornerstone for the definition of the DEMETER Reference Architecture and the DEMETER Agriculture Information Model (AIM) which were developed thanks to the collaboration of the pilots' stakeholders.
Likewise, these pilots are fundamental to validate the interoperability and integration of the information provided by different platforms and the components defined in the DEMETER Reference Architecture.
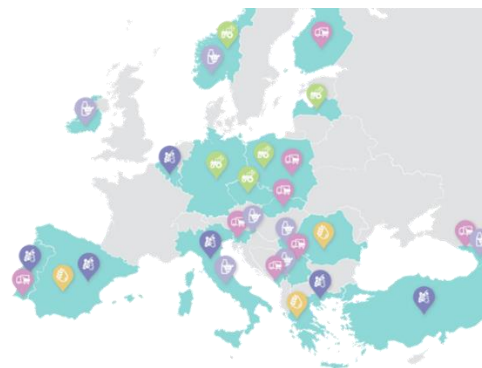
In this whitepaper, we describe the information relevant for these pilots, as well as the extensions they are expected to take advantage of the components stored in the DEMETER Enabler Hub (DEH). These components have been designed and developed thanks to the work carried out in both WP2 and WP4 for helping the farmer in their daily work making it more efficient and providing recommendations based on historical information and other predictions.

1   ARABLE CROPS: Water and Energy Management

This first category groups pilots addressing smart water and energy management, smart irrigation and corn production management. Despite the inherent particularities associated with the use of different partners' platforms which expose different APIs and endpoints, they use the following information:

- Soil and weather information provided by soil sensors and weather stations
- Satellite images and the different indices they offer among others
- UAV-collected multispectral and thermal imagery.

Additionally, thanks to the DEMETER architecture, and the components provided by the DEH[1], these pilots are being improved and extended in their functionalities. More specifically, below we have highlighted the ones more relevant for these pilots.

- 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.).
- 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
- 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.

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[1] The DEMETER Enabler Hub (DEH) is the digital space dedicated to end-users of DEMETER where they will be able to create and register their own resources.

2   ARABLE CROPS: Agricultural Machinery, Precision Farming

The second group of this classification comprises pilots addressing agricultural machinery monitoring, automated documentation for estimating costs of agriculture tasks, decision support system (DSS) for farm management, and finally the development of services to support the benchmarking on the productivity and sustainability of farms.

The data used by these pilots varies because of the broad spectrum covered inside this cluster. Below we can find a summarized list of the more relevant information used by these pilots:

- Engine detailed information including torque, humidity, fresh air flow, temperatures, pressures, fuel consumption, operation hours, ...
- Geospatial data: Location, Velocity, Movement patterns, GPS
- Farm data: Historical farm statistics, Farm crop data
- Water data: Hydrants water flow, Water consumption
- Farm data: Historical farm statistics, Farm crop data
- Statistics on agricultural holdings in Europe including information on the volume of production, quantity of production materials used, farm profits, etc.
- Eurostat – agri-environmental indicators linked dataset
- Agromarket data – data on current agro-market prices for several categories

Unlike the previous cluster, two of the pilots, instead of integrating the information inside the DEMETER Architecture, process the information locally due to specific limitations and restrictions associated to the sensitiveness of the information. Nevertheless, components such as the Data Quality Assessment from the DEMETER Architecture are employed for improving the quality of the information. The others follow a similar approach as pilots in the previous cluster extending the initial operation mode by using the following components stored in the DEH:

- Crop, water and fertiliser information
- Farm information
- Control of machines
- Data analysis and data preparation
- Financial Performance Benchmarking
- 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 (Farm Accountancy Data Network) 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)

3 FRUITS AND VEGETABLES: Healthy and High-Quality Crops

This third cluster groups pilots that cover DSS related with olives and potatoes farms, as well as woody crops. Another interesting aspect covered by one of these pilots is the control of pest on fruit fly which impacts numerous fruit trees. The output of these DSS intend to advise the farmers about how to optimise the irrigation, inform them about field management practices such as optimal harvest date, how to control possible pest threats and also provide indicators about these activities.

These pilots use the following information:
- Geospatial data: Location, Field polygon
- Crop data: Variety, Planting density, Year of planting
- Remote Sensing Multi-Temporal Imagery data
- Meteorological data)
- Soil data
- Farm data: Historical farm statistics, Irrigation logs, Fertilization log, Crop protection treatment logs, Data on crop phenological observations.
- 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
- 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

Moreover, these pilots leverage the potential of DEMETER by using specific components available on the DEMETER Hub repository so that they can connect to external weather data sources, or could employ machine learning tools for optimal irrigation, yield prediction, olive yield estimation, for modelling the olive phonology, as well as to evaluate the performance of the production. Other applications that

these components could have comes in the direction of pest detection and treatment application, and others related to irrigation optimisation using even fertilisation.

4 LIVESTOCK: Animal Health, High Quality and Optimal Management of Animal Products

In this fourth section, DEMETER covers the livestock sector dealing, not only with the animal welfare in farms, but also with products derived from them. The pilots grouped in this fourth cluster therefore aim at making a more efficient use of the digital tools farmers can use, to optimise animal well-being standards focused on cows and chicken farms and milk quality. To achieve these goals, these pilots make use of the following information:

- Basic cow data (age, lactation no., days in milk, breed) information
- Rumination, eating habits, respiration monitoring, animal rest (lactations, activity, total daily lying and many others)
- Milk production: milking frequency, milk yield, milk quality, milk composition analysis.
- Farm benchmarking data which will also include historical farm data
- Climate data in the poultry barn: Air temperature, Air humidity, Air flow, CO_2/NH_3 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

Taking advantage of the components defined in the DEMETER Architecture, these pilots have their initial functionalities extended by using specific DSS components related to Animal welfare, milk quality traceability, benchmarking, or silo monitoring services.

5 CROSS-SECTORIAL: Full Supply Chain, Interoperability, Robotics

Finally, this last cluster explores four pilots of different sectors: agriculture, apiculture and livestock. They deal with the supply chain and interoperability of the orchards/vineyards management, milk quality, pollination optimisation and poultry industry.

The information used by these pilots have been mostly described in the previous clusters, nevertheless, below we highlight specific information relevant for the aspects indicated in the cluster:

- Soil, UGV (e.g. images), environmental, geospatial, satellite and milk data used to detect the best moment for harvesting.
- 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.
- 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.
- Hive location and conditions (temperature, weight etc.)
- Pollination data: pollination need, saturation, invitations, offers, agreements
- Alerts: Pollination invitations, pollination offers, sprayings, pests, others

Likewise with other pilots in previous clusters, these pilots take advantage of the components that will be developed in the frame of DEMETER project for adopting and integrating new functionalities thanks to the use of the repository provided by the DEMTER Enabler Hub. For this heterogeneous clusters, we can highlight components for machinery sprayer control, decision support and data analytics for pests and disease during the plant growing period, pollination requirement estimation and matching components, or components for assessing food travel and the cold chain.

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