PROJECT FINAL REPORT

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4.1.1 An executive summary

The main goal of VINTAGE project is to fine tune wine production within the vineyard, abating seasonal variability issues with the application of information technologies, maximizing the oenological potential of the vineyards and providing the vine-growers with continuous up-to-date information through **user friendly web and mobile interfaces** and **an advanced solution for the decisional support** (DSS).

The VINTAGE DSS is a **decision support system** designed and implemented to satisfy vineyard monitoring and management needs of vine growers associations, allowing each user to **benefit from timely** and **accurate information and suggestions**, without disrupting the historically consolidated agronomical traditions and practices. To this scope, the system run data collected by local wireless monitoring stations (**WMS**), remote sensing data, field data provided by users, and weather forecasts.

In this context, mathematical modelling plays a central role in the VINTAGE system and regards mainly solar radiation, temperature and precipitation data interpolation over complex terrain, plant development and growth, soil moisture status, grape quality assessment and disease risk. Data and models output are then used by an artificial intelligence component to derive specific advice to growers. Indeed, the VINTAGE system is interactively accessed by means of a fully geographical web interface and a lighter mobile one.

The VINTAGE system was designed and implemented by a European consortium including researchers and engineers from Italy (Labor, Arpa, Mavigex), France (Université de Bourgogne, Inra) and Austria (TU Wien). Moreover, **four pilot areas** were set up during the project, in cooperation with the local vine growers associations involved: in **Italy** (Vignaioli Piemontesi), **France** (BIVB), **Spain** (Rioja) and **Portugal** (Andovi). In these pilots area, WMS were installed and tested, and local field data were collected to calibrate and test the different version of VINTAGE system prototypes implemented.

The users requirements and needs were collected and analysed with specific interviews to base on them system and interface design, whilst prototypes were successively proposed for usability test and analysis, before the implementation of the final VINTAGE **HMI** (human machine interface).

The VINTAGE HMI shows for each pilot area the geographical representation of vineyards, location and data from the WMS, three-days local weather forecasts and includes a large number of products from models and DSS. It also allows users to draw, characterize and save new vineyards, and to fill the field book, providing important feedback to the VINTAGE system. Indeed, the mobile interface allows the users to load data from the field taking advantage of the mobile GPS for localization.

Products available from the web VINTAGE HMI can be grouped in the following categories: localized prescriptions from the DSS, weather data and forecasts, remote sensing data (surface moisture and vegetation index), soil conditions (moisture profile and temperature), and vine status variables (phenology, leaf area and grape growth), disease risk from WMS and models (powdry and downy mildew), system configuration and management tools.

In 2015 the system entered its operational phase, managed by the mentioned associations together with Gaiag, an Italian start-up company charged with running the system and expanding the market use of VINTAGE.

4.1.2 A summary description of project context and objectives

4.1.2.1 Project Context

The VINTAGE project was conceived on the assumption that *"Wine is a cultural and economic asset for Europe and, therefore, a product upon which European countries have built their own fortunes"*. However, in recent years, New World producers (mostly South Africa, Australia and South America) had been taking advantage of several compelling market trends, attacking the **European leadership** in this sector: the consumers are reported to perceive price/quality ratio as too high for European wines. Hence, European vine-growers need increasing support from technology to face the challenges from the global market and, therefore, have focused their interest towards the application of precision viticulture technologies in order to re-gain a pivotal role at international level.

Not only global market competition but also global **climate change** is currently putting a strain on wine production in Europe. Climate change in the Euro-Mediterranean region, where most of European wine is produced, manifests itself not only with rising temperatures and lower summer precipitation, but also through an enhanced variability of weather patterns that puts many traditional management concepts on hold. Plant phenology and growth, grape quality and sugar content, harvest management and timing, disease risk, all these aspects are changing fast and traditional calendars are more and more being challenged.

In this context, **precision viticulture** is one of the systems to be adopted to adapt European agriculture, and more specifically viticulture, to these new constraints and challenges. Local monitoring with automated and wireless stations and sensors, remote sensing from space and drones, crop phenology and growth modelling, interactive web tools, geographical information systems are examples of technologies to be implemented to face the new wine growing situation. Of course users should not be bothered with excessive technicalities, and difficult interfaces, so a deep understanding of their needs is essential to design and implement simple but powerful support tools like the one envisaged and carried out with the VINTAGE project.

With this context in mind, **four relevant European Associations of wine producers** - Vignaioli Piemontesi (Italy), Grupo De Empresas Vinícolas De Rioja (Spain), Bureau Interprofessionnel des Vins de Bourgogne (France) and Associacao Nacional das Denominações de Origem Vitivinícolas (Portugal) - have decided to endorse the VINTAGE project in order to support their associates for **increasing their competitiveness**. In fact, the project aims at providing final users with a low cost and easy to use web based integrated management solution in order to **support wine producers** throughout the vineyard life cycle (from planting to harvesting), to improve their productivity as well as **to optimise the use of resources** (irrigation water, fertilizers, pesticides, manpower).

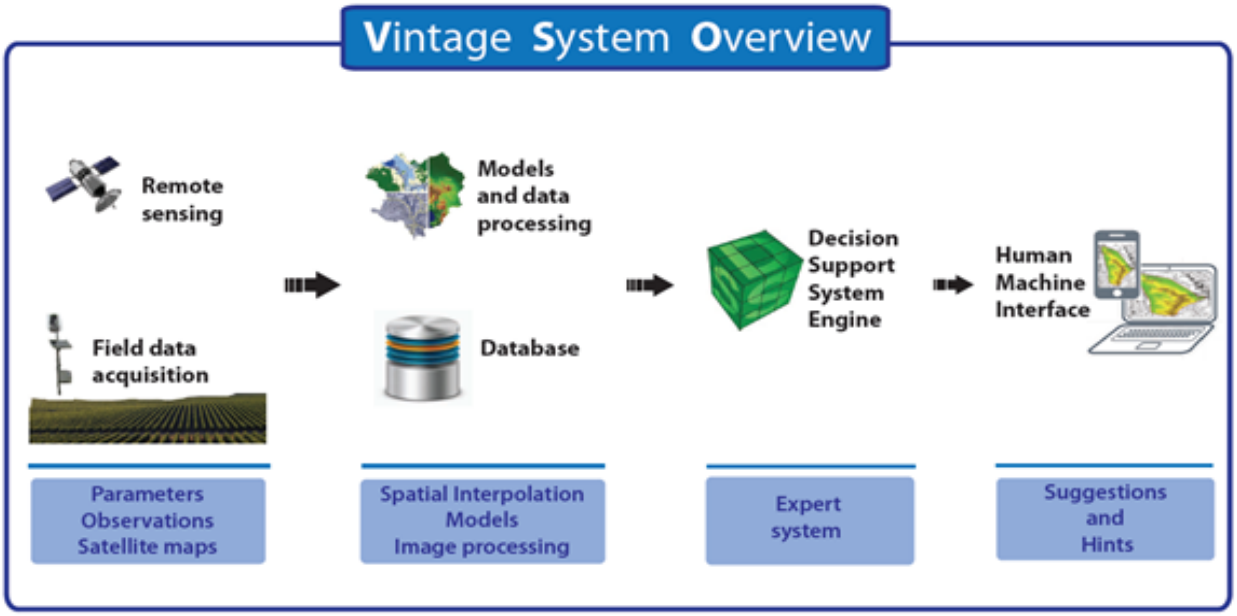


Figure 1: VINTAGE system concept

4.1.2.2 Project Objectives

In this vision, VINTAGE project makes available to the Associations and SMEs involved an **innovative management platform** (including both SW and HW components) able to provide novel precision viticulture services to their associated members and to new customers.

In order to fulfil the application needs expressed by the users, the VINTAGE system was conceived and developed on the basis of the following modules:

1. Local monitoring

An accurate, precise and continuous **monitoring** of the grape environment is an issue in precision viticulture. This implies the identification of the most important forcing variables, as well as the design of a reliable and affordable monitoring system.

Weather and soil are the most relevant **environmental factors** affecting grape development and growth. In particular, air temperature and radiation controls the phenology and the photosynthesis, respectively; knowing humidity and leaf wetness is essential for the risk of diseases; wind intensity affects evapotranspiration; precipitation represents the main water input in the soil, and soil humidity is the major water reservoir for the plant.

These environmental variables could be used as they are in a Decision Support System, but mainly they should feed agrometeorological **simulation models**. A sufficiently dense network is needed to monitor these variables outside and inside the vineyards. The aim of this monitoring network (WMSs network) is to reproduce the weather, soil spatial and temporal variability. In each pilot area, a specific network was deployed, taking into account the land characteristics.

2. Real time vineyard modelling and state assessment

Vineyards are typically located in hilly areas, characterised by a complex topography that deeply influences the spatial variability of weather variables. Therefore, a detailed **spatialization** of these

variables is required to a reliable computation of the grapevine growth and development, soil water availability and disease risks. Several algorithms are available to take into account the topography of the area (elevation, slope, aspect, shadowing) in the spatialization of key variables as solar irradiance, air temperature and relative humidity. Using a high resolution **Digital Elevation Model** (DEM), as the new NASA SRTM at 1-arc second resolution, very detailed output maps could be produced.

Also the **soil-water model** has to provide high resolution information on the soil moisture and water availability; therefore, we used Criteria3D model, that solves the equations of water transport on surface and within the soil in a 3D domain and is fully coupled with the plant transpiration and soil evaporation. The phenology model has to compute the plant development during both dormancy and growing season, while the plant growth model has to estimate the **biomass accumulation**, the water uptake, the wine yield and **berry sugar content**. Plant growth in VINTAGE is computed by simulating the photosynthetic process at hourly time step, specifically the carbon assimilation is determined through the Farquhar photosynthesis model, with a procedure which computes stomatal conductance too. The plant growth and soil-water models have to be able to change their state in case of **field operations** carried out by users and recorded in the VINTAGE field book, as irrigations, green pruning or cluster thinning.

A new model for assessing the berry sugar content from cumulated heat units and assimilated solar radiation has been developed; its calibration was possible thanks to the availability of the high resolution maps of air temperature and solar irradiance. Finally, the risk related to the main **grapevine diseases** (downy and powdery mildew) has to be estimated with great accuracy both in time and space, in order to optimize the phytosanitary operations. This is achieved by using state-of-the-art pest models, forced by high resolution weather maps.

3. Geographical access to information and data

Presenting data in visual format is much more direct and effective with respect to numerical format. Being ease-of-use and providing a satisfactory experience to no-expert users, two objectives of the VINTAGE system, having a **geographic representation** of information and data was a straightforward choice for the VINTAGE system and HMI. This was realized through the insertion into the **system architecture** of a Geographic Information System (**GIS**) server, able to **process** and **store geographic data** in an **optimized** fashion.

4. HMI design and implementation based on user needs

The Human Machine Interface (**HMI**) is the VINTAGE system component that allows the users to interact with all system sub-modules. It is thus of primary importance to present the users with an easy-to-use, custom interface that is specifically tailored to their usage needs.

Users have been at the center of the whole design process of the VINTAGE HMI, starting from usage scenario identification and requirement collection and analysis. Design and development followed a **user centric approach** and specific **usability guidelines/heuristics**.

In general, a heuristic is a guideline or a general principle that is conceived to drive the design activity and to assess the performed design choices. In particular, an overall approach **entailing five subsequent steps (planes**) has been followed, continuously and progressively involving all system stakeholders through both questionnaires and hands-on sessions with early and advanced HMI prototypes.

With specific references to dedicated user sessions, the physical sessions have been carried out with specific focus on **usability** and **acceptance** in France, Italy, and Spain pilots, with users belonging to the SME associations participating to the VINTAGE project. In this context, the user acceptance was evaluated as a confirmation that the results of **the VINTAGE project activities are both relevant and on-target** with the users' needs, paving the way for the following industrialization and the future **commercial exploitation** of the system.

5. Feedback from the growers

User feedback on the performed vineyard interventions and actions is of primary importance to ensure that the output of agro-weather models and the decision support system are aligned to the actual current status of the vineyard.

The **VINTAGE HMI** provides a **specific insertion form** for the users in order to input the type of performed action and its magnitude. A wide number of actions can be inserted relevant to the different phonological phases of plants.

The diary **of the past inserted actions** is visualized in a specific section of the interface, allowing the users to easily keep track of the performed interventions.

6. DSS and Prescriptions

By using the knowledge of fully-experienced experts, coded in form of a set of rules, an ontology-based artificial intelligence subsystem (**DSS Engine**) is in charge of integrating indices and estimations computed starting from satellite data, models and data coming from Wireless Monitoring Stations (WMS) in order to help users to take decisions. Indeed, **hints** and **suggestions** based on a large set of data, evidences, observations and best practice are provided to domain experts (e.g. agronomists) and final users (e.g. grape growers, winemakers, etc.). To his scope, three kind of key-information are generated:

- ✓ what is suggested/recommended to do;
- ✓ list of facts that justify the suggestion (data, observations etc.);
- ✓ knowledge rules involved.

The Decision Support System (**DSS**) as a whole provides all the information needed by the user, such as weather forecast, vegetative status, infection risks. The DSS-Engine has been studied for offering even something more: to take the right decision, the farmer should be a true expert and, what is worst, should spend a lot of time analyzing every day almost all the DSS's data. However, the DSS-Engine has been conceived to accomplish exactly this role (and even something more) for the farmer, providing him/her with its "pills of wise" every day, simple but powerful targeted advices.

During its development, the DSS has been assessed by users, whose feedbacks have been used for the identification of the improvements and re-design activities needed to realise the final system.

Many DSS exist in grapevine and wine industry for vineyard management. The specificities of VINTAGE, which, to our knowledge, are innovative features not provided so far in agriculture, lie in the integration of the following services related to the DSS:

- A **wide set of recommendations**, covering almost all of the major aspects of vineyard yearly management, i.e.: plant disease management, winter and summer pruning, irrigation, soil management, yield management, grape ripening follow up and harvest date.
- Decision support is provided at the subplot spatial level, which allows the grape-grower to apply **a differential management** of each plot. Traditionally, most of the grapevine management operations are performed at the same period considering the vineyard as a whole. VINTAGE offers the possibility to limit interventions only where they are needed, providing therefore time, financial and environmental benefits
- The VINTAGE system models **integrate the feedback** of each interventions performed by the grape-growers and the accounts therefore for the past actions prior to further advices. In addition, the field diary facilitates a differential management of each plot for the grape-grower, as a track of each operation is kept within the system and remains available through the VINTAGE HMI.

The development of precision viticulture is made difficult because of the complexity brought by the separation of field intervention in space and time within the vineyard. VINTAGE, by integrating precise advices, field interventions feedback and a vineyard management diary, responds to this major challenge, and aims at allowing a more precise and relevant vineyard management.

4.1.3 A description of the main S&T results/foregrounds

4.1.3.1 Project pilots

The VINTAGE system required **an operational testing** in commercial vineyards to both provide a demonstration to grape-growers of the whole set of features available in the system, through the Human Machine Interface, and to assess the relevance of the VINTAGE system as a whole for integrated vineyard management via its decision support system. This testing was led in *four commercial vineyards* called *"pilots",* with the aim to:

- **evaluate** different deployment efforts and the relative efficiency of VINTAGE hardware, software and their integration though "real-world" test-drives;
- **assess** the quality of VINTAGE plant and soil models, by comparing their spatialized outputs over the pilots area to UAV, satellite and field observations;
- **test** the relevance of the DSS recommendations to end-users, via ex-post comparisons of VINTAGE simulated actions to grape-growers actual vineyard operations;
- **offer** demonstrations to local grape-growers and consultants of the VINTAGE system.

The major interests of the grape-growers (or other potential end users) in VINTAGE features are likely to differ depending on the soil, climate and socio-economical context of the region. Therefore, **four pilots** were selected in remote grape growing regions, with different environment and productions modes, as well as equipped with Weather Monitoring Stations, geographic and agronomic data (Digital Terrain Model, vineyard geodatabase, agronomical characteristics) and monitored (field observation and grape growers survey) in Italy, France, Spain and Portugal.

Pilot #1 - Italy

The first pilot, named ***Fontanafredda***, is located in Piedmont region (Italy), in the controlled and guaranteed appellation of origin (DOCG) Barolo wine growing region. The typical morphology of this area (historically called Langhe) is regular hills with gentle slopes and rounded ridges. The pilot area corresponds to the central part of Fontanafredda vineyards (property of a member of Vignaioli Piemontesi consortium), and is composed by 51 hectares of grapevines, located mostly on the west exposed slopes of a hill, and range from 200 m asl to 320 m asl.

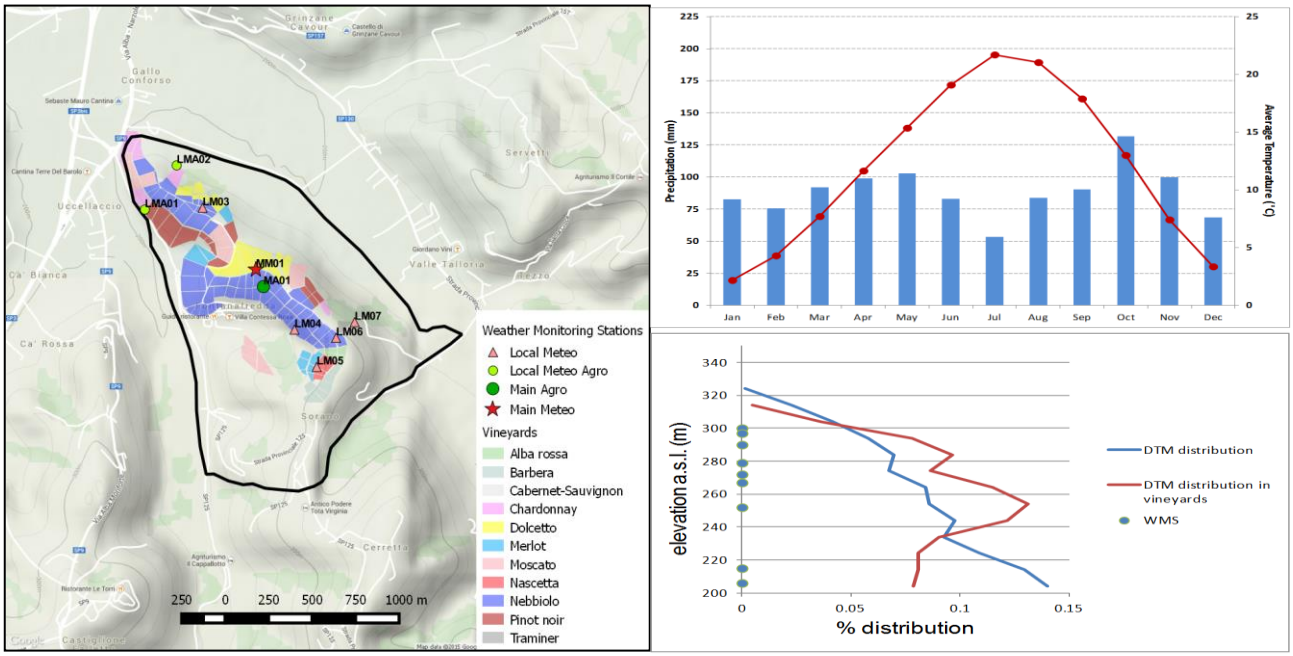


Figure 2: Pilot #1: Fontanafredda (Italy). Geographic overview, with simulation domain (black line), vineyards and WMS locations; monthly precipitation and average temperatures 1960-1990 (from Climatic Research Unit, University of East Anglia); distribution of DTM pixels (total and in vineyards)

The area is characterized by a mid-latitude temperate climate wet in all seasons, with warm summer, and an average annual precipitation and mean temperature of 1100 mm and 12.1 °C, respectively. Soils are rather homogenous on the whole vertical profile. They are basic (pH > 8) and calcaric with a loamy texture and a high amount of fine silt. The spatial homogeneity of soils within the entire pilot vineyard, despite considerable terrain variations, is striking. Hence, the choice of considering a unique soil in the simulation is well justified.

The vineyard is composed of 11 different grapevine cultivars, amongst which Nebbiolo, an autochthonous variety, is dominant. Most of the area is in production, although about 2 ha is composed of young vines (< 2 ha). The grapevines are trained perpendicularly to the slope direction, as traditionally performed in this wine growing region (Langhe). The training system is Vertical Shoot Positioning (VSP). Winter pruning is almost completely “Guyot simple”, but a few vineyards are cordon pruned. Row spacing is 3 m and it is homogenous within the whole pilot. The distance between the plants within the row is 1 m, with thus a planting density of 3300 plants per ha. The trunk height (distance from the soil to the canopy) is 0.5 m. The canopy height is 1.5 m. The major diseases are mildews (powdery and downy mildew) and require about 10 spraying each, yearly.

The domain area has been defined so to include most of the vineyards belonging to the

Fontanafredda estate. The limits have been extended to the main hydrological catchment closures. The domain has an area of 206 ha. The DTM (Digital Terrain Model) was derived from the cartographic archive of Region Piemonte ("Modelli digitali del terreno da CTRN 1:10.000 (passo 10 m) – Modello altezze filtrato"). The original 10 m DTM has been resampled to 20 m, in order to have a comparable resolution to the other pilots.

Pilot #2 - France

The second pilot is located in the ***Saint-Romain*** village vineyards (Burgundy, France). Saint-Romain is a protected appellation of origin appellation (AOP / AOC) of 97 ha of vineyards.

The area is characterized by a mid-latitude temperate climate wet in all seasons, with warm summer and an average annual precipitation and mean temperature of 780 mm and 10.2 °C, respectively. The soils are shallow calcaric-cambisols (from 0.3 to 1.5 meters depth) overlying late Jurassic limestone (top and lower part of the slope) and marls (mid to upper-slope). The texture is silty clay loamy, with moderate skeleton. The lower horizon is much more compacted, with a low hydraulic conductivity.

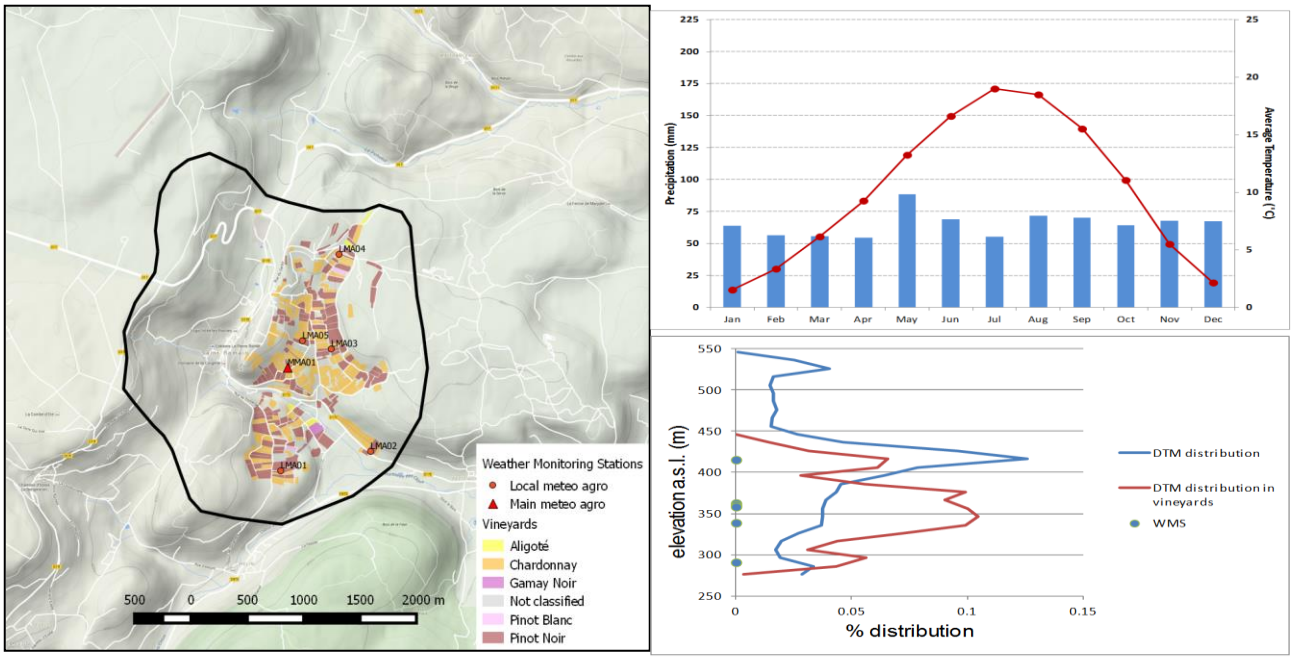


Figure 3: Saint-Romain (France) pilot

Commercial vineyards of Saint-Romain appellation area is planted mainly with Chardonnay and Pinot noir, while minor varieties are Aligoté, Gamay Noir, Pinot Blanc. The training system is vertical shoot position (VSP) with simple Guyot pruning, with one spur and an 8 buds cane. Plant spacing is 1 m between plants within the row and 1.1 m between the rows (9090 vines/ha). The trunk height ranged from 0.35 to 0.45 m and the shoots are mechanically trimmed several times starting from early June at about 1.0 m to 1.2 m high. Soil is managed by tillage.

The domain area has been defined so to include the vine territory of Saint Roman, and extended to the main hydrological catchment closures. The domain has an area of 651 ha. The DTM over the domain area was taken from 30 m dataset ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer, Global Digital Elevation Model Version 2), and resampled at 20 m resolution.

With respect to Pilot #1, we have here a more pronounced variability in elevation, ranging from 270 to 550 for total domain, and from 270 to 430 for vineyards. The stations heights are adequately representing the vineyard elevations. The domain covers a wider range of elevations, particularly higher zones, which have been included in the domain for hydrological coherence.

Pilot #3 - Spain

The third pilot is located in ***Aldeanueva de Ebro*** (Spain), a municipality of the **Rioja** region. Rioja is also the homonymous appellation of controlled origin (DOC), which is the most ancient in Spain. The territory is located in Valley of Ebro River, where the environment is modeled by surface water flow, with frequent terraces and alluvial fans.

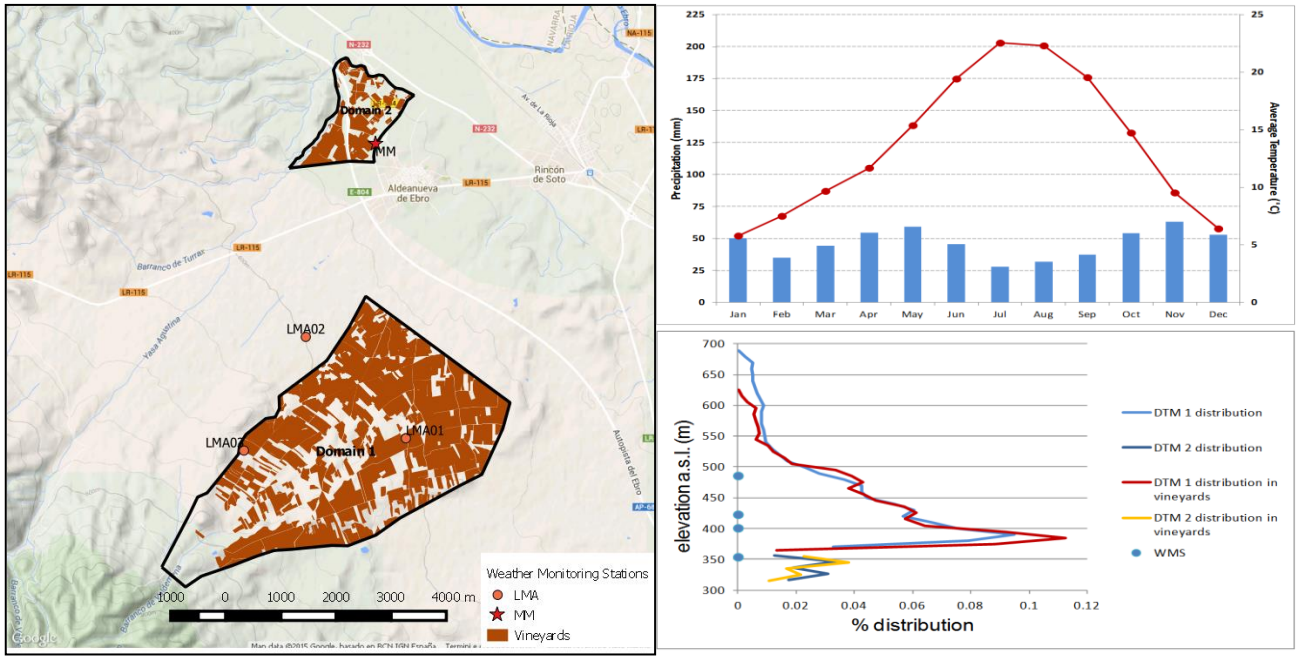


Figure 4: Rioja (Spain) pilot

The area is transitional between temperate and arid climates, with a hot summer. It presents an average annual precipitation and mean temperature of 550 mm and 13.7 °C, respectively. The area represents the most arid conditions among the project pilots. The soils are mainly shallow alluvial and ferrous-clay, with a loam-sandy loam the texture, and abundant skeleton, especially below the surface. The water regime is typically arid (the soil remains dry for most of the year).

The autochthone Tempranillo covers around 75% of the vineyards, and the simulations were conducted considering this variety all over the area. The vineyards are trained mostly into goblet (“vaso”), with a row spacing of nearly 3 m and a plant distance within the row of 1 m, with thus a planting density of 3300 plants per ha. The trunk height (distance from the soil to the canopy) is 0.2 m and the canopy height is 0.8 m.

With the aim of testing the whole VINTAGE system for multiple not contiguous areas, two separate domain areas were defined, one bigger (1576 ha) including a small catchment in the hilly area and one smaller (205 ha) in the plain near the Ebro river and close to Aldeanueva. The data for producing the DTM (Digital Terrain Model) over the domain area were taken from 30 m dataset SRTM (Shuttle Radar Topography Mission). Considering the spatial extent of the pilot, the variability in elevation is quite limited, being mostly limited in the range 300-500 m.

Pilot #4 - Portugal

The forth pilot is located in the vineyards (18 ha) of the experimental farm ***Amândio Galhano,*** in the municipality of Arcos de Valdevez, Viana do Castelo district (Portugal). The farm is inside the Demarcated Region of ***Vinho Verde*** (subarea of Lima) and sits on the right side of the Lima River. The region is exposed to the Atlantic Ocean influence, being this even more reinforced by the main river valleys orientation that facilitates the maritime winds' penetration.

The area is characterized by a mid-latitude temperate climate with dry and warm summer, with an average annual precipitation and mean temperature of 1470 mm and 12.2 °C, respectively. The annual precipitation is high, compared to the other pilot areas, but they are concentrated in winter, autumn and spring. Soils are mainly granite-based and sandy. All the 52 varieties (white and red) allowed in the Vinho Verde region are grown in "Amândio Galhano" farm. Modern training systems are conducted in this region, namely “Bardo” (low trellis) and “Cordão” (upward and/or overlapping).

The data for producing the DTM (Digital Terrain Model) over the domain area were taken from 30 m dataset SRTM (Shuttle Radar Topography Mission). The domain has an extent of 36 ha, the smallest extent within VINTAGE, with 18 ha of vineyards. Considering the limited spatial extent, the variability in elevation is high. The three stations have been positioned in order to sample this range.

4.1.3.2 Wireless Monitoring Stations

Overview and main achievements

The technical activities concerning WMS (Wireless Monitoring Stations) have been carried out focusing on modularity and smartness criteria, in order to make possible to use a single electronics (VUB – Vintage Universal Board) as well as single mechanical methods for every pilot.

The electronic core is the VUB, namely a PCB (Printed Circuit Board) conceived and designed in order to fulfill the several needs, first of all the possibility to manage the different configuration options (Main and Local stations). Each typology allows to interface a set of sensors, therefore different circuital parts, such as integrated circuits and custom blocks, devoted to special measurements. Here are some among the most notable VUB’s features, developed and implemented throughout the project lifetime:

- ✓ Sensors interface
- ✓ RTC sync, on-board battery
- ✓ Remote reprogramming
- ✓ EEprom storage
- ✓ USB connection
- ✓ Smart remote reset
- ✓ Web service data interface

Figure 5: VINTAGE Universal Board

The WMSs are agro-weather stations. They, relying on a flexible setup, can assume several shapes, according to the local measurement needs. It is an important achievement for the agro-weather field, because final users, by means of such architecture, are now able to optimize costs as

well as overall system's reliability. In fact, it is possible to use a single electronic board for all the expected typologies, simply mounting the needed components and leaving empty the remaining footprints. Also the firmware is modular, since a single programming packet is needed for every station: users can remotely assign the station typology, so that the station automatically runs the portion of code related to the wanted typology.

Alongside this, the mechanical mounting solutions are modular and easy to implement: we have constantly taken into account ease of installation, under both a mechanical and electronic point of view. We have two fundamental kinds of WMS, in turn composed of further sub-types of stations.

Main stations: a landmark for agro-weather variables, supplying data for model calculations:

- **Main Meteo**: air temperature and humidity, wind speed and direction, atmospheric pressure, solar radiation, precipitation (Fontanafredda, Rioja).
- **Main Agro**: soil profile, involving three or more volumetric sensors: soil water content (to be calculated through apparent dielectric permittivity), soil temperature, soil salinity (to be calculated through electrical conductivity).
- **Main Meteo-Agro**: an integration of the previous two Main stations (Burgundy, Vinho Verde).

Local stations: several stations placed in selected spots over the area, supplying data for interpolations:

- **Local Meteo**: air temperature and humidity (Fontanafredda).
- **Local Agro**: canopy temperature and humidity, leaf wetness, soil water content/temperature/salinity, precipitation (never installed).
- **Local Meteo-Agro**: an integration of the previous Local stations (Fontanafredda, Burgundy, Rioja, Vinho Verde).

Figure 6: main stations (on the left) and local stations (on the right)

Pilots installations

Several hardware/firmware versions have been released, improving time after time the features as well as overall reliability. Following the mentioned approach, we carried out the following installations/interventions:

2013, March **Fontanafredda** (Italy)	Nine Wireless Monitoring Stations (WMS) have been installed within the Fontanafredda area: a main meteorological station (Main Meteo), a main agrometeorological station (Main Agro), five meteorological stations (Local Meteo) and two agrometeorological stations (Local Meteo Agro).
2014, January **Burgundy** (France)	Six Wireless Monitoring Stations (WMS) have been installed within the Saint-Romain area: a main agrometeorological station (Main Meteo Agro) and five Local Meteo-Agro stations. In Burgundy each WMS was placed close to the selected row on a telescopic metal pole with metal stirrups and not directly on the row first pole; poles used in rows are too short and weak for using it overall with large use of “Tracteur enjambeur”, a row straddling tractor.
2014, July **La Rioja** (Spain)	Four Wireless Monitoring Stations (WMS) have been installed in Aldeanueva de Ebro, a main meteorological station (Main Meteo) and three Local Meteo-Agro stations. In order to simulate vine development since the beginning of the last available season (2013-2014) within the project, meteorological data from surrounding stations were also collected, belonging to the Rioja regional network.
2014, October **Fontanafredda** (upgrade)	The first pilot ever installed has been upgraded, in order to line up the components with the latest ones.
2015, February **Vinho-Verde** (Portugal)	Three Wireless Monitoring Stations (WMS) have been installed in the Quinta Campos de Lima area: a main agrometeorological station (Main Meteo Agro), and two Local Meteo-Agro stations.

Each installation gave us the chance to face several matters, concerning the technologic aspects. The deliverables within WP2 focused on the progresses of the activities made throughout the design and prototyping stages. It has been possible to improve the overall constructive solutions, such as electronics (hardware and firmware) as well as mechanics, leading - especially for the latest pilots - to a mature and really reliable architecture. The D4.2 and its Annex – WMS User Guide, focuses on the topics linked to tests and electronics-firmware-mechanics releases.

Deviations and further improvements

The four pilots, among other things, gave us the chance to face issues linked to security on the field. The stations are normally placed in open and often unfenced areas, so they might be exposed to thefts and manumissions. Indeed, we experienced two thefts in La Rioja. In that area the stations

are installed in vineyards not surrounded by neither industrial nor residential neighborhoods. The nearest town (Aldeanueva de Ebro) is some kilometers far from the innermost station. Therefore, unlike other installations such as Fontanafredda (where the vineyards, even if unfenced, are closer to the winery, industrial area as well as offices), in lonely locations the risks linked to thefts and manumissions may dramatically increase.

In order to grant the highest possible modularity, the WMSs have been conceived as an easy assembly of several parts. In this way we have managed several installation scenarios according to the requirements stated in the WP1. On the other hand, this kind of system may have some downsides, such as ease of disassembly and manumission. It is desirable, in case of further improvements and developments, to study proper mechanical solutions able to combine modularity and security. For instance a base platform made of concrete, to be arranged on the selected spot, could support a metal structure and the metal pole, where in turn the plastic case as well as the sensors could be installed.

The agricultural environment presents many issues to be faced. For instance, the leaves growing all around the station, as well as bad weather conditions may affect the normal propagation of the radio waves. Moreover, as we had to work in open areas, often far from the nearest town, the policy adopted by the local phone companies concerning data connection might result quite odd.

In those cases, we needed proper equipments, such as specific antennas and cables, in order to guarantee the signal as best as possible. We experienced such problem right in Rioja, where we adopted a reliable solution. We experienced significant issues linked to likely not compliant behavior of the GSM/GPRS cells in the selected area. Therefore we implemented a stronger solution, installing a professional outdoor logarithmic and directional antenna with high gain. The antenna was aimed toward the nearest cell. Finally, the mentioned D4.2 – Annex - WMS User Guide provides guidelines useful for improving the electronics, including errata and further hardware improvements.

4.1.3.3 Models and Remote Sensing

Agro-meteorological models

One of the main components of the VINTAGE Decision Support System is the agro-meteorological models chain that is daily executed. The modeling chain (see figure) starts from the input of data stored in the database, in more detail the observed hourly data from WMS, the field observations recorded by the users in the field book and the previous state variables (needed to restart the models). Weather data are interpolated at hourly time step on the whole domain area, by using spatialization algorithms specifically designed for each variable. For instance, the solar radiation model takes into account information as sun position and topography of the area (slope, aspect, shadowing). The resulting hourly weather maps are input for the other models.

The grapevine model computes the plant development during both dormancy and growing season, while the plant growth model estimates the biomass accumulation, the berry sugar content and the water uptake. In order to establish the best harvest time a new model which computes sugar concentration starting at veraison was developed (Bois *et al*., 2014).

The soil-water model is based on Criteria3D (Bittelli *et al*., 2010) that solves the equations of water transport on surface and within the soil in a discrete 3D domain with an integrated finite difference

scheme. The water model is fully coupled with plant transpiration and soil evaporation.

Finally, the phytosanitary models provide pest risk information for downy mildew, powdery mildew and botrytis risk at harvesting. At the end of the daily cycle, model output and state variables are stored in the VINTAGE database.

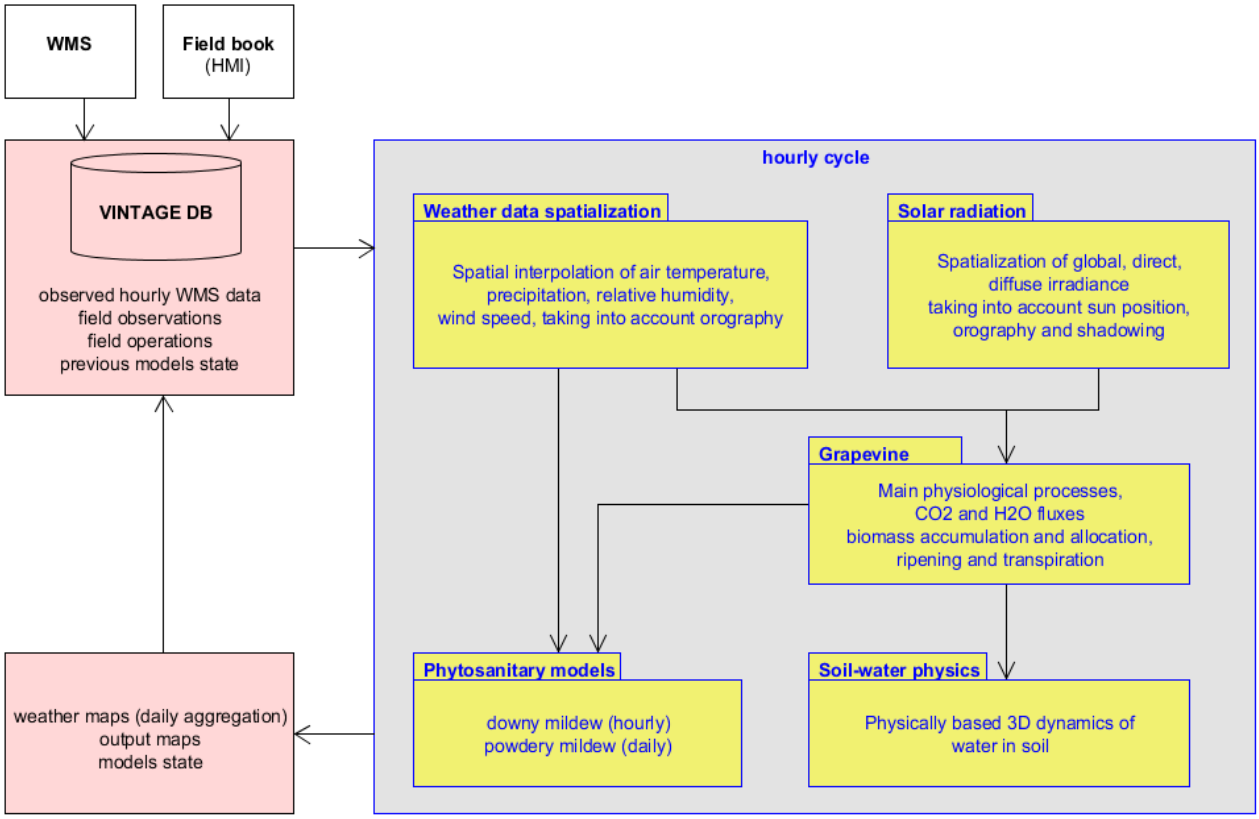


Figure 7: VINTAGE modeling scheme

Model testing

Three types of test have been carried out on the models:

1. **consistence**: the output must be consistent with input data
2. **robustness**: the models must continue operating despite lack of input
3. **accuracy**: the output must reflect field reality in a satisfactory manner

For each of the three test types, a figure reporting the successful completion is reported.

Consistence*:* the variability of maximum Brix degree map for 2014 season is consistent with the variety map on Fontanafredda pilot. As expected, the higher values of maximum Brix degree are forecast in the areas corresponding to the Nebbiolo cultivar (purple areas), that usually reaches higher Brix degree than the other cultivars.

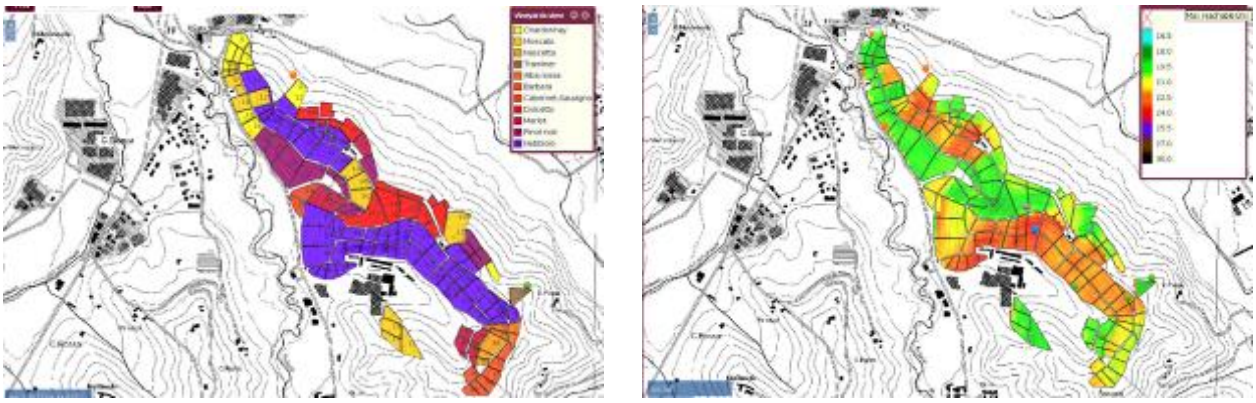


Figure 8: on the left, the vineyard and cultivar map of Fontanafredda pilot, on the right the maximum Brix degree [°Bx] estimated by the plant model, for 2014 season.

Robustness: the following figure shows an example of daily aggregation of hourly interpolated weather data, in a day in which no WMS data are available. Several different strategies to cover missing data have been implemented in the Vintage system, in this case boundary data from the regional agro-meteorological network of Rioja were used.

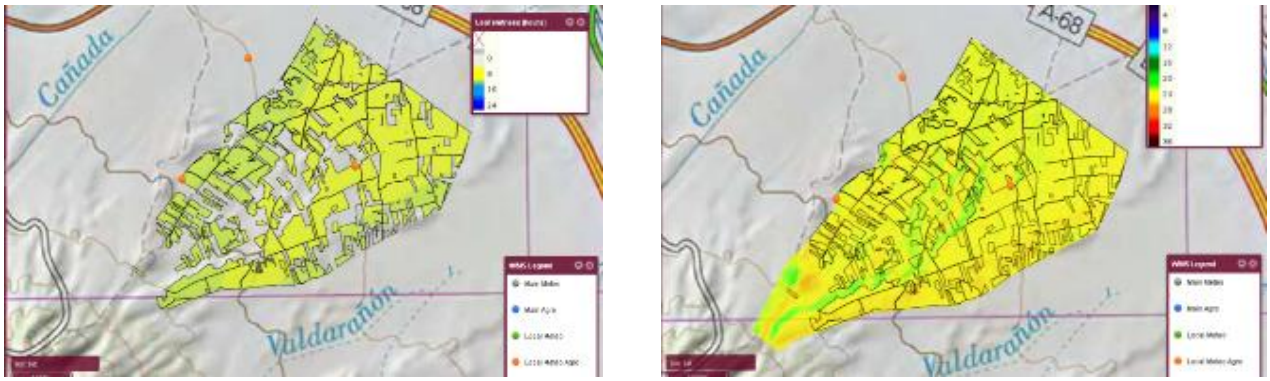


Figure 9: Rioja pilot. On the left, map of daily leaf wetness (number of hours) on May 28th , 2014, on the right, map of daily solar global radiation (MJ m-2) on May 29th , 2014.

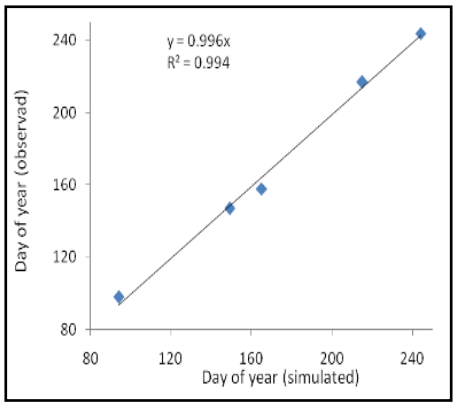


Figure 10: Rioja 2014, Tempranillo variety, phenological stages date simulated vs observed

Accuracy: the figure on the left shows the time course of Tempranillo variety in 2014 for the La Rioja pilot. The correspondence between simulated and observed data gave good results.

In order to quantify accuracy of the outputs we have drawn the scatter plot of simulated versus observed date of phenological stages 2,3,4,5 and 6. The linear regression has a R2 = 0.99 and the root mean square error (RMSE) is 4.2 days.

Model validation

Grapevine development and grape ripening was monitored in Fontanafredda pilot on five experimental blocks of Nebbiolo and Chardonnay varieties (figure). In Saint Romain, six experimental plots were monitored in commercial vineyards of Chardonnay variety. In the following paragraphs the results of model validation on these plots are shown.

The following figure shows the scatter plot of observed versus simulated dates of two main phenological stages (bud burst and veraison) in Fontanafredda pilot. VINTAGE simulates with good agreement the spatial/varietal variability of bud burst dates (correlation coefficient R^2=0.83) and veraison (Root Mean Squared Error RMSE=4.5 days), especially for Merlot, Chardonnay and Moscato.

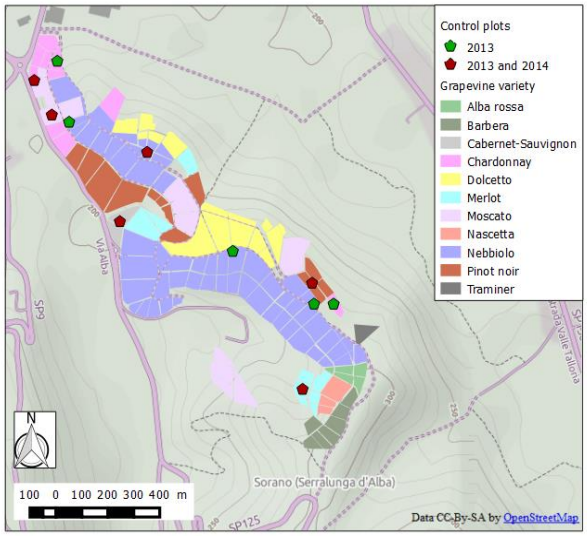


Figure 11: grapevine observations on the Fontanafredda (Italy) pilot.

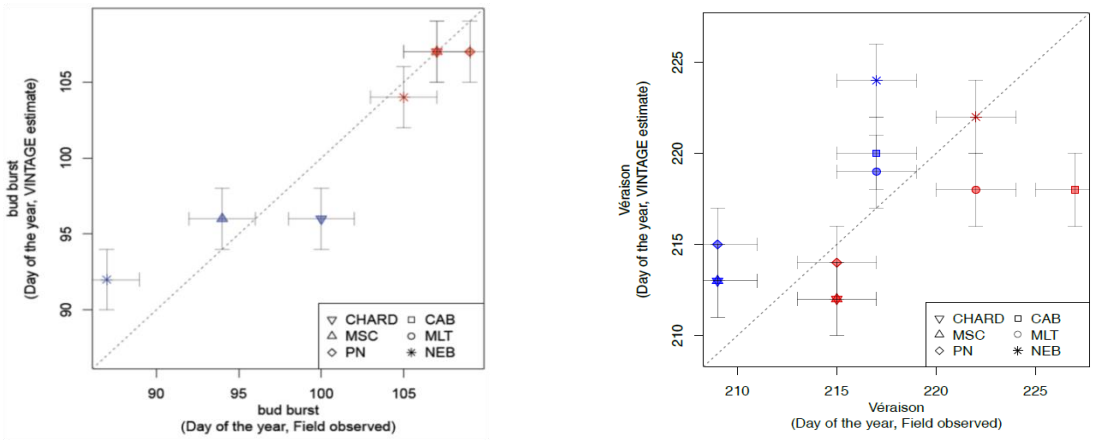
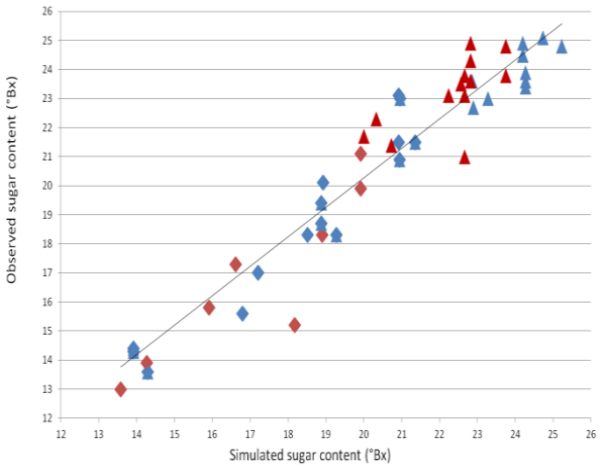


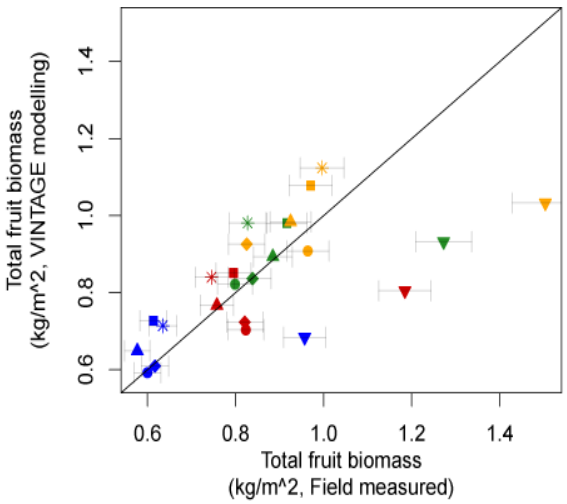
Figure 12: comparison of bud burst (left) and veraison (right) dates observed in the field with simulated date by Vintage model. Red symbols: year 2013, blue symbols: year 2014.

Next figure shows the scatter plot of sugar content simulated (x-axis) against observed (y-axis) in the Fontanafredda pilot, for two varieties (Chardonnay and Nebbiolo)**,** for years 2013 and 2014. The results of comparison, summarized in the table, show that the ripening model has a good performance in simulating the sugar content for both the varieties analyzed.



	RMSE (°Bx)	R^2
Total	1.01	0.93
Chardonnay	1.08	0.89
Nebbiolo	1.15	0.92
2013	0.84	0.95
2014	1.21	0.91

Figure 13: on the left, simulated vs observed sugar content for all plots of Fontanafredda pilot. Data are divided into Chardonnay (rhombi) and Nebbiolo (triangles), the colors distinguish season 2013 (blue) from season 2014 (red). On the right, statistical indices of the comparison.



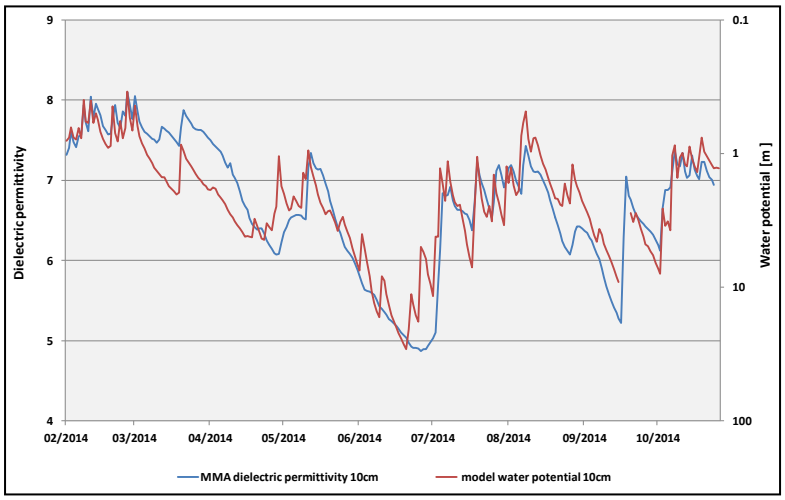
Fruit development into the model was assessed by comparing Vintage fruit biomass output to field measured data of berry weight and crop yield (i.e. fruit biomass) in the Burgundy (France) pilot. The model dry fruit biomass estimates follow globally the observed berry weight variations in space and time, with a underestimation in one plot (triangles), probably due to the lack of information on field operations and soil fertility, which might dramatically change the plant behavior.

Figure 14: measured vs estimated fresh fruit biomass in Burgundy (France) pilot.

The water potential computed by the soil-water model have been compared with observed WMS data of soil relative dielectric permittivity. The two variables are related and can be directly compared using two different scales: linear for permittivity and a log scale for the water potential.

The next figure shows the temporal plot of permittivity measured by Main-Agro WMS in Burgundy pilot at the depth of 10 cm and estimated water potential in the same location and

Figure 15: Burgundy 2014 - relative dielectric permittivity measured by WMS (blue line, left axis) at depth of 10 cm vs estimated water potential (red line, right axis, log scale)



depth, for a 9-month period in 2014. The good correlation (R^2 = 0.77) between observed and simulated values in a time period that includes a recharge period (winter-spring season) and a drying period (summer season) indicates the good representativeness of the model for soil water processes (i.e. water flows and evaporation) and plant water extraction (i.e. transpiration).

The effect of irrigation management was tested in the Rioja (Spain) pilot, where one of the most important problems for wine growers is given by water scarcity. The irrigation test, summarized in table below, shows that the simulation differ drastically due to the different water management. The maximal LAI increases from 1.7 to 2.3, while the yield increases from 32.4 hl/ha to 47.5 hl/ha.

variable	control	irrigated	unit
transpiration	101	145	mm
LAI max	1.7	2.3	-
yield	32.4	47.5	hl/ha

Table 1: Rioja pilot 2014 - model estimation of total transpiration, maximal leaf area index and wine yield, for two adjacent vineyards, the first not irrigated (control), the second irrigated (60 mm).

In order to assess the accuracy of this simulation, without available observed data, we compared the model results to the mean historical yields of Tempranillo for not irrigated (37 hl/ha) and irrigated (46.5 hl/ha) stands. Historical mean values are comparable to the model outputs.

Remote Sensing Data for Viticulture

Data from sensors mounted on satellites, airplanes and Unmanned Areal Vehicles (UAVs) can be used to retrieve geophysical variables and parameters over winegrowing areas. They provide valuable information about the status of the vine plants and grapes, the soil, and the weather conditions in a consistent manner and covering the whole vineyard area.

Soil Hydrology from Satellite Remote Sensing

In order to supply the VINTAGE DSS and HMI with hydrological data from remote sensing, two independent satellite data processing engines have been developed, tested and integrated. These are, for the kilometric surface soil moisture (1km SSM), the ASCAT_H08SSM_processor and, for hectometric SSM, the SAR_SSM_processor. The software are embedded in the Remote Sensing Virtual Machine (VM_RemoteSensing) and is using genuine and open-source Python and C libraries. The RS_VM is operated by an Ubuntu 12.04 LTS system.

Kilometric Surface Soil Moisture: 1km SSM from ASCAT_H08SSM_processor

The ASCAT_H08SSM_processor at the VM_RemoteSensing contains software for automatic satellite data acquisition and the processing of these to surface soil moisture (SSM). Data are taken from the spaceborne MetOp ASCAT radar scatterometer sensor with a downscaled resolution of 1km (from native 25km) and is available at a 1-2 day frequency. The figure gives an impression of the ASCAT 1km SSM as it appears in the VINTAGE HMI.

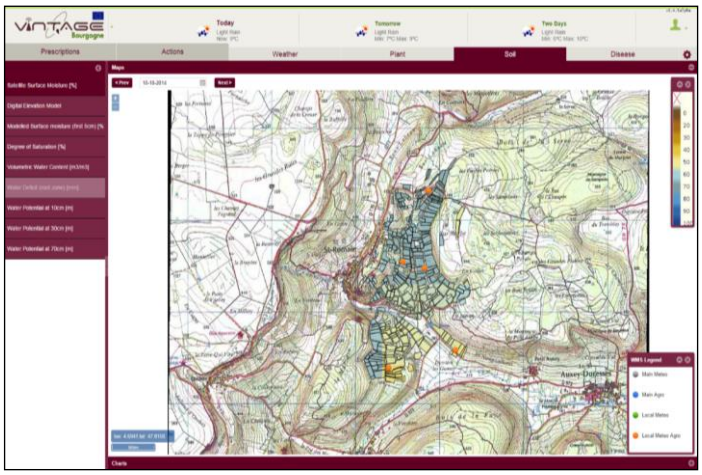


Figure 16: ASCAT 1km SSM in Burgundy in October 2013 as displayed in the online VINTAGE DSS interface.

The scheme below shows the functionality of the ASCAT_H08SSM_processor and its integration in the VINTAGE system. The scheme illustrates also the data flow in form of different stages of the satellite data: green represents the raw data; blue stands for the (pre-processed) data; purple introduces the VINTAGE-specific processing in the RS_VM; orange specifies the data uptake and transformation to information by the VINTAGE model, DSS, and HMI.

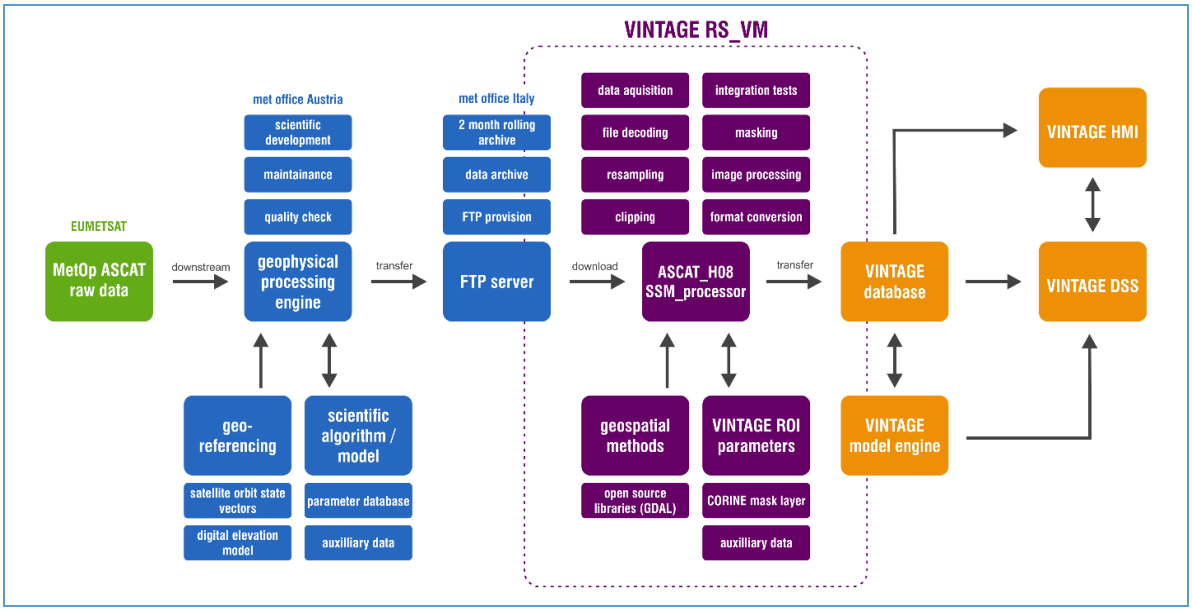


Figure 17: the ASCAT_H08SSM_processor as integrated part of the dataflow from raw satellite data to information for VINTAGE users (explained in the text).

The software is fully automated and self-testing and designed for an automatic daily run. It is initiated daily at 04:30 AM by the operating system and all settings for the processing can be changed in s workflow-python script.

The ASCAT 1km SSM was evaluated against ground data from VINTAGE Wireless Monitoring Stations (WMS) as well as the VINTAGE CRITERIA model over the VINTAGE pilot areas in Italy

and France. Spearman correlation analyses between soil surface wetness (SSM) and soil profile wetness (SWI) from ASCAT 1km, WMS and model outputs were carried out. The datasets were matched in regards of temporal coverage and their cumulative distribution functions previous to the correlation. On average among several locations of WMSs, these Spearman correlation coefficients (rho) have been obtained:

Fontanafredda				**Burgundy**		
ave. rho	WMS	Model		*ave. rho*	WMS	Model
ASCAT SSM	0.83	0.77		ASCAT SSM	0.44	0.76
ASCAT SWI	0.89	0.84		ASCAT SWI	0.56	0.82

Table 2: Spearman coefficients between time series of ASCAT SSM/SWI and WMS/Model soil wetness at the VINTAGE pilots in Fontanafredda and Burgundy.

The ASCAT 1km SSM was also validated over European vine growing areas in general. More specifically, against external in-situ precipitation and model soil moisture data. This study was presented at the ESA Living Symposium in Edinburgh 2013 (Bauer-Marschallinger et al,.2013)

Hectometric Surface Soil Moisture: 150 m SSM from SAR_SSM_Processor

The SAR_SSM_processor features the processing of georeferenced SAR images from (historic) Envisat ASAR or Sentinel-1 Interferometric Wide Swath (IWS) to SSM images with 150m resolution. Once the input image file is provided, the software takes care of the SSM geophysical parameter retrieval. Resampling, reprojection, SSM retrieval, clipping, local incidence angle normalisation, image processing and format conversion to GeoTiff is handled automatically.

The SAR_SSM_processor builds upon newly developed SAR processing software with a spatial-reference-grid optimised to high resolution satellite imagery as well as a dedicated parameter database from the Envisat ASAR 2004-2012 radar backscatter history. The optimised spatial referencing system named Equi7 Grid was presented at the EGU General Assembly in Vienna, 2014 (Bauer-Marschallinger et al., 2014). The parameter database comprises a reference for wet and dry conditions, radar incidence angles and a slope parameter. Furthermore, a mask based on the European CORINE Land Cover program was added. With this positive mask, it is ensured that soil moisture is only retrieved over areas covered by arable soil.

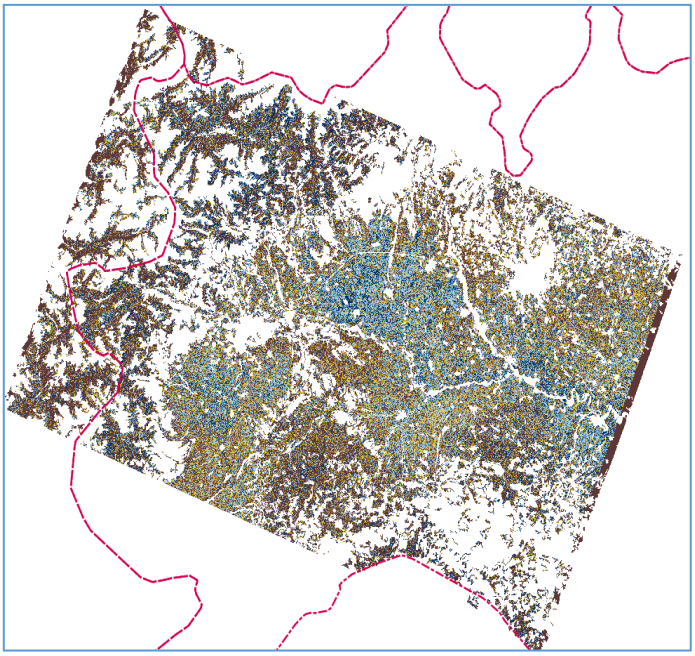


Figure 18: SSM derived from a Sentinel-1 scene on 2015/03/03 over Piemonte. Masked areas in white. Italy boundaries in red

Optical remote sensing

Two scales were considered: the decametric scale corresponding to LANDSAT8 or the future Sentinel data. And the decimetric scale corresponding to UAV imagery.

Decametric data: LANDSAT8

A code that allows downloading of LANDSAT8 images has been proposed. A matlab code is then used to extract the data over the site of interest, calibrate the raw reflectance channels, compute NDVI and provides a corresponding image in geotiff format. The following image gives an illustration over the Fontanafredda site.

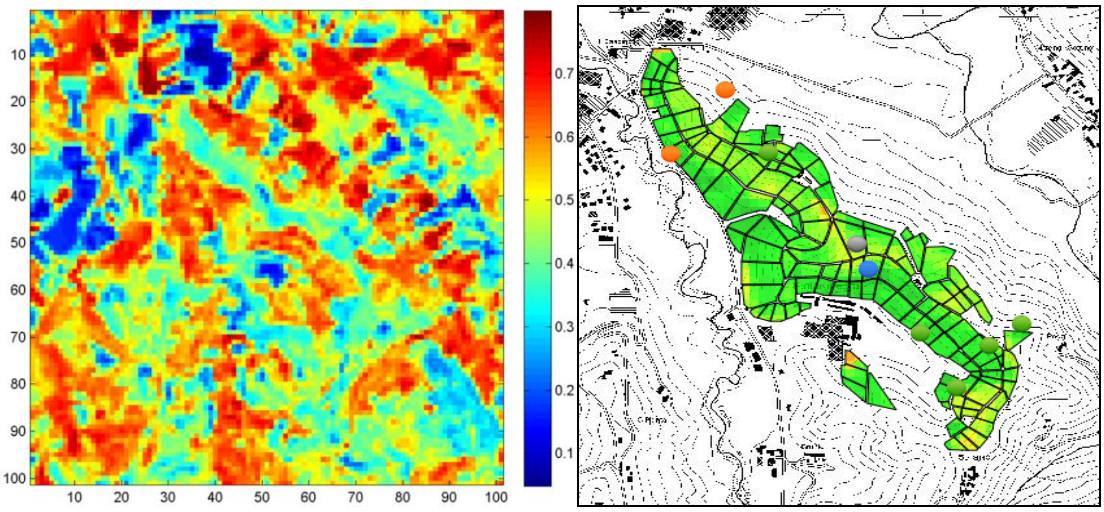


Figure 19: a typical NDVI image over Fontanafredda site on the left. On the right, the NDVI values on April 2014, 4th, as displayed in the Vintage interface.

The Normalized Difference Vegetation Index (NDVI) data extracted from LANDSAT products have a decametric resolution, consistent with the model outputs. Unfortunately they have serious issues both on availability and usability of data. For instance, in the Burgundy pilot very few images were actually usable because of the high cloud and haze occurrence and the fact that Saint-Romain site is accessed from only a single LANDSAT8 track. In Fontanafredda instead, the information is contaminated by the strong signal coming from the grass growing between the rows making the interpretation difficult in terms of vineyard characteristics. This is illustrated on the previous figure that shows high NDVI values in figure (green areas) refer mainly to grass presence, because in April the grapevine is in an early vegetative state.

A code has been developed, written in matlab to estimate the biophysical variables of the vineyard from LANDSAT8 data. The following principles have been used, based on a look up table approach as illustrated in following figure. The MCRM model is used here to simulate the canopy reflectance of the vineyard and build a series of look up tables corresponding to the specific characteristics of the vineyard and view or sun positions.

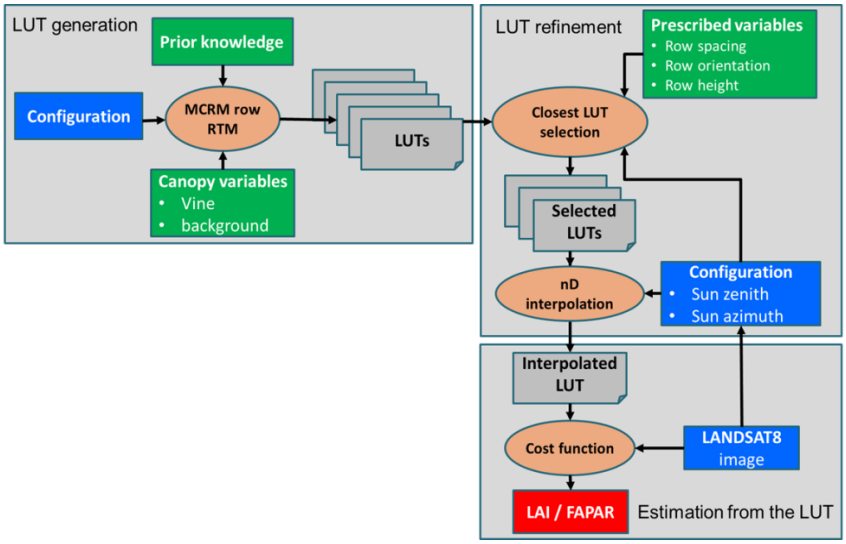


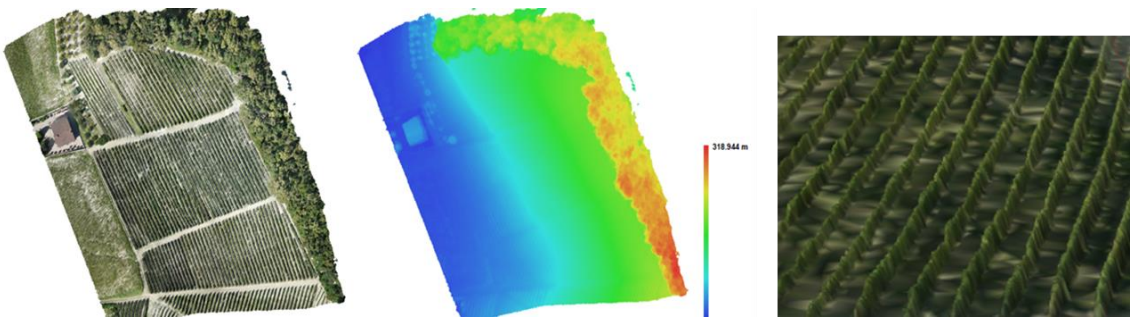
Figure 20: schema of the estimation of some vineyard characteristics from the LANDSAT 8 images.

The principles of the algorithm are sketched in the following figure. It is composed of 3 main steps:

- The generation of the LUTs. For each combination of prescribed variables, a specific LUT is generated by running the reflectance model over the all combinations of unknown variables.
- The LUTs corresponding to the prescribed variables the closest to the actual ones corresponding to the field considered are selected and then interpolated.
- Finally, the unknown variables are estimated by selecting the cases corresponding to the minimum of the cost function.

Decimetric resolution: UAV

The high resolution images are first pre-processed using AGISOFT-PHOTOSCAN or PIX4D to get an ortho-image of the mosaic of individual images. In addition to the ortho-image, a 3D cloud of points may be generated from which the row characteristics are computed over 10 m x 10 m pixels. A matlab code has been developed to estimate the row characteristics from the 3D point cloud. The code allows extracting the following characteristics: orientation, height, width, spacing, cover fraction and fraction of missing row. The method was validated and shows relatively good performances as demonstrated by the following figure.



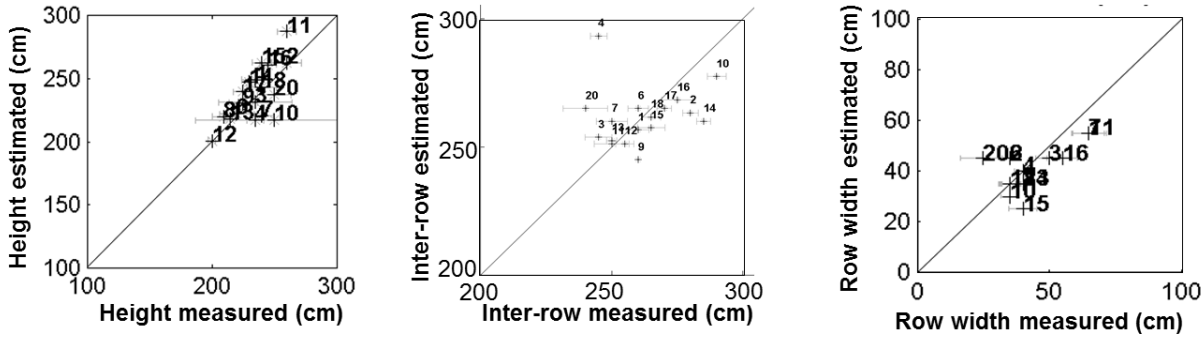


Figure 21: on top the mosaic of RGB images taken from the UAV (left), the derived DEM (center) and a view of the 3D mesh of a vineyard. On the bottom, the validation of the Estimates of row characteristics.

In addition to the row structure, the RGB cameras used have been transformed to be sensitive to the near infrared and compute a proxy of NDVI that provides the vigour of the row. However, because of possible green grass between the rows, the NDVI should be computed on the row itself. A procedure has been developed to first calibrate the raw digital counts and get a NDVI proxy from the filtered images. Then a procedure is applied to extract the row values and then define an average vigour over 10m x 10m pixels.

4.1.3.4 Decision support system

DSS-Engine

The Decision Support System (DSS) provide all the information needed by the user such weather forecast, vegetative status, infection risks. The DSS-Engine has been studied for offer even something more: to take the right decision, the farmer she should be a true expert and, what is worst, should spend lot of time analyzing every day almost all the DSS's data but the DSS-Engine does exactly this (and even something more) for the farmer and offers to him/her every day its "pills of wise", simple but powerful targeted advices.

The VINTAGE DSS has the aim of automatically suggesting advices, and generate notifications and alerts along different phenological phases of the grapevine cycle. Vintage is able to provide, by a rule based engine, the same kind of suggestions that a team of expert specialists in precision viticulture could supply in almost any single situation. The next figure shows the simplified structure of the DSS,

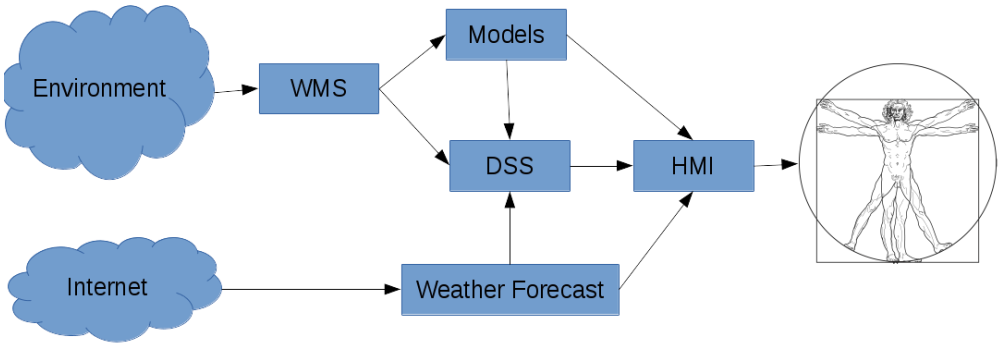


Figure 22: DSS structure

by which it is possible to identify the following main modules:

- **Wireless Monitoring Systems** (WMSs) collect data, which are then used as an input within both DSS and models.
- The **Models** elaborate data and provide the results to the DSS.
- The **Weather Forecast** plug-in collects weather web service information and elaborates weather advices disclosed to the DSS system.
- The **DSS** generates advices throughout the year, which are made available on the HMI that displays information to the final user.
- The **HMI** shows to the user the information required, the advices, allowed to manage the configuration and collect the users' feedbacks.

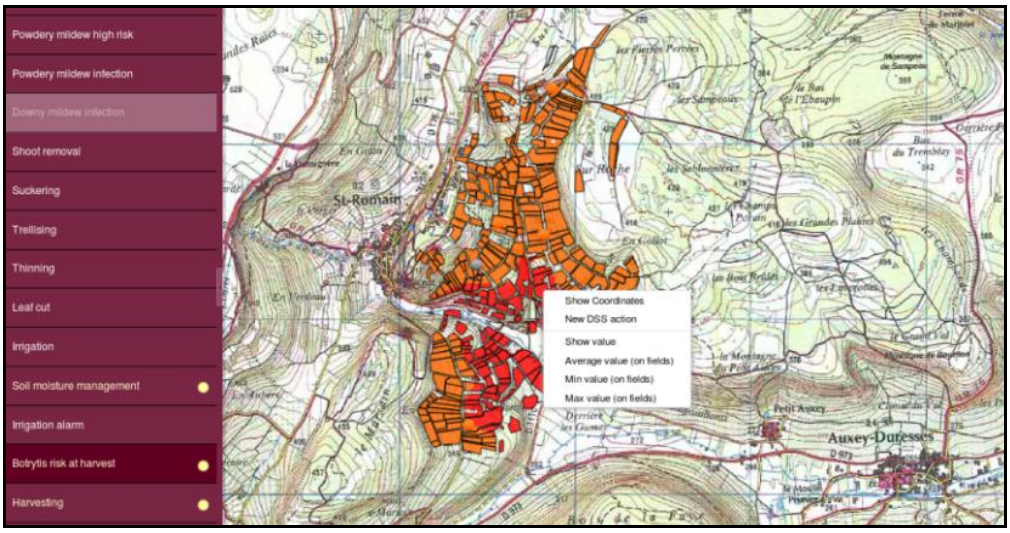


Figure 23: Botrytis risk at harvest prescription, Burgundy (France) pilot, October 25th 2013.

As shown in the previous figure, each one of the possible advice is clearly displayed on the map and the farmer can obtain all the specifications needed with simple clicking on the area of interest. If the user click on the "Show value" on the map, a window will be open displaying advice information and if the farmer is interested in which are the reasons for that advice, "Details" button will show the rules and the variables involved in the advice. The following images show an example of advice and advice details.

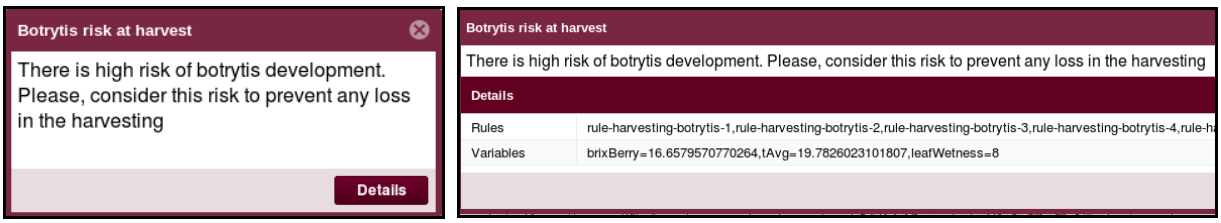


Figure 24: advice example (on the left) and advice's details example (on the right).

The DSS-Engine is a state-of-art non-evolutive Artificial Intelligence System that uses a Rule Based Engine for support the farmer in his/her work. This is one of the developed rules that defined the

DSS-engine's behaviour:

```
[rule-harvesting-1: (?obsvi:phenoPhase ?val1)
ge(?val1, 5.5)
le(?val1, 6)
(?obsvi:brixMax ?val2)
(?obsvi:brixBerry ?val3)
difference(?val2, ?val3, ?val4)
ge(?val4, 2.0)
lessThan(?val4, 3.1)
(?obsvi:harvestingPerformed ?val5)
equal(?val5, 0)-> (?obsvi:harvestingOutput "1")]
```

The rules has been developed in collaboration with the Europe's major vineyard experts, has been tailored around to the final users' specific wills of and has been studied to be applicable almost in every climate and cultivar condition and law limitations. A complex work of data mining allowed us to identify the behaviour of certain parameters and predict their value for help the farmer even more to planed his/her future activities.

The land is virtually divided into pixels (small sub-fields of less than 5 by 5 meters) and the analysis is realized (every night some minute after midnight) for all the pixel so every advice will be exactly focused on a specific and well defined area. The figure on the right shows the detailed view of how the DSS-engine works.

From the WMS's, the environmental data comes into the Database. Here the Aggregation System, the Mathematical Model System and the Data-Mining Computation Module provided the needed data to the DSS-engine.

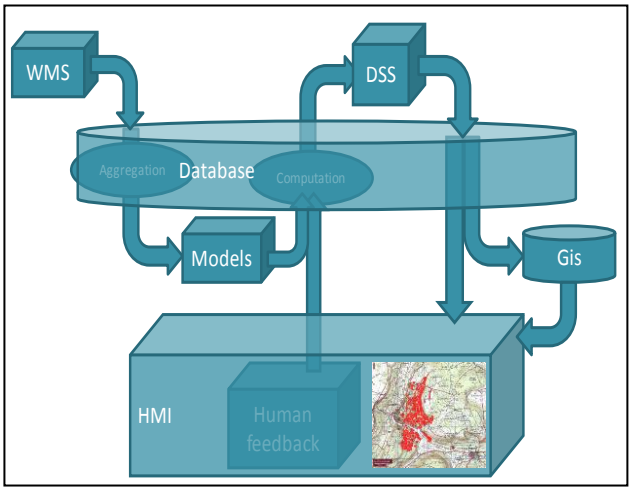


Figure 25: VINTAGE data flow

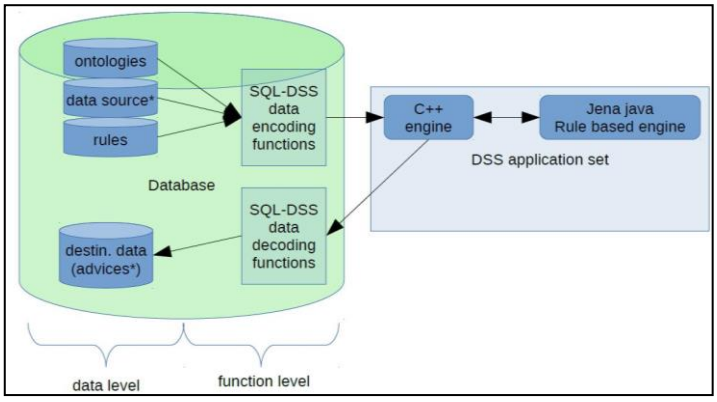


Figure 26: inside the DSS-engine

The DSS output is used both directly, into the HMI for justifying the advices, and indirectly, filtered by the GIS engine for obtaining the maps to display.

The human feedback and the field book (or actions' diary) are also used as input by the DSS to "learn" and to provide a more interactive advice's set. The figure on the left shows the structure of the software system.

In the following figure is possible to have an idea how the DSS engine is layered:

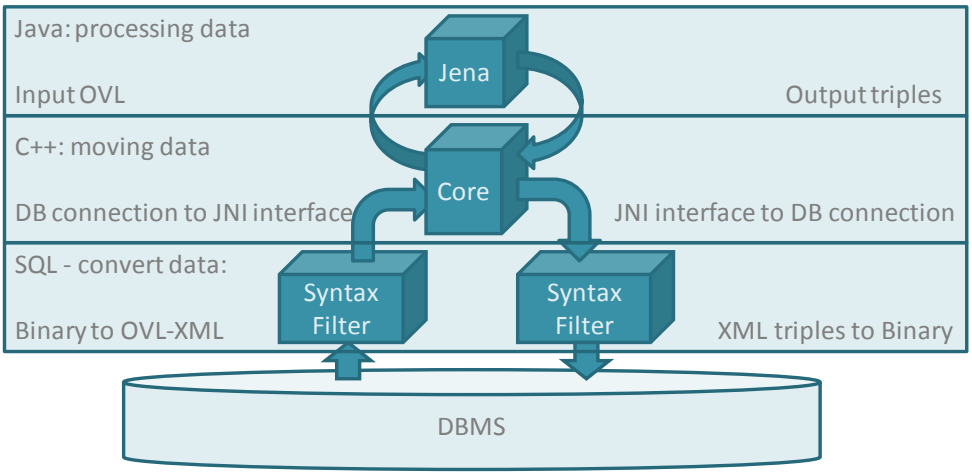


Figure 27: DSS's computational layering

When a specific vineyard operation has been realized, the farmer should inform the system so the DSS-engine could stop annoying the user with no more necessary specific advice.

The DSS-engine attitude has been checked deeply with a test-case session that involved over one thousand auxiliary maps generated to offer a wide vision of the DSS-engine's behaviour. Moreover, there are two level to be considered, technical and logical and each one of them has been verified accurately.

Our checklist was:

1. Test each single component (where possible)
2. Probe all possible partial-grouped subsystems
3. Global test
4. Behaviour test

Here we report an example of test-case:

Test	
Target Variable:	oidioOutput
Target Value	{4}
Involved rules:	rule-powdery-mildew-no-organic-2 rule-powdery-mildew-no-organic-3
Conditions:	out_phenophase∈ (4.5...5.5) out_shootleafnumber∈ (4.0...∞) out_powderypir∈ (0.1...∞) organic_farming= 0
Existing map affected	Pixel ON if OidioOutput∈ {4}

Test	
Matching map to be created	Pixel ON if out_phenophase∈ (0.0...5.0]

Whole of them were organized into tables like those one to simplify the search of the dates. Next figure shows a comparison of two maps, the first one generated by the DSS-engine and the other one created externally (called debug map) on a more simple and focused law.

Figure 28: DSS's advice map (on the left) and debug map (on the right)

DSS validation

An *ex-post* comparison of VINTAGE recommendations to “traditional” (i.e. non-VINTAGE supported) grape growers field interventions was performed once the VINTAGE DSS was fully operational. To achieve this comparison, field dairy were collected from grape growers by means of surveys: 4 grape growers were interviewed in Saint-Romain (pilot #2, France) and provided information concerning vineyard interventions (trellising, trimming, pest control spraying). In Fontanafredda (pilot #1, Italy) data was collected from the Fontanafredda winery, the unique grower for the whole pilot.

In both areas, diseases management draws most of the attention of the growers during the vegetative cycle. Despite the effort of phytopharmaceutical input limitation by grape-growers lately, viticulture in these areas still requires considerable amount of phytosanitary products to protect the vineyard, mostly for mildews control, i.e. powdery and downy mildews (respectively caused by *Erysiphe necator* and *Plasmopara viticola* polycyclic microorganisms). Hence, a particular attention has been placed on the VINTAGE DSS recommendations concerning the control of these diseases.

Finally the following DSS recommendations/alerts were assessed:

- **Canopy management**: trellising (i.e. gathering the plant shoot in vertical position within the row axes, so that no branches fall between the rows, where trailers might damage the branches) and trimming (i.e. cutting, once trellising has been performed, the shoot tips growing outside the row axis) operations. According to the simulated shoot length and the phenological cycles, VINTAGE DSS indicates when these operations have to be performed.
- **Powdery and downy mildews.** . According to the sporulation events and the potential infection risks of the plant by *Erysiphe necator* (powdery mildew agent) and *Plasmopara viticola* (Downy mildew agent), treatments alerts or high risk alerts are provided by the VINTAGE DSS

Trellising and trimming support of VINTAGE

These canopy control operations (trellising and trimming) timing was extracted from the VINTAGE DSS in pilot #2 location (Saint-Romain, Burgundy, France) for the 6 experimental plots used for plant model validation plots, and compared to operations performed by the grape growers on these plots.

Within the VINTAGE DSS, the timing rules of both of these operations are mostly based upon plant modelling, and especially shoot length. For both operations, the VINTAGE system provides similar timing to those performed in the field. The differences in timing are usually less than a week, which is fully acceptable for such types of vineyard actions. The largest differences are found between 2013 trimming, were 10 days of difference are found in 4 from the 6 experimental plots.

For the plot located at the highest elevation, for which grapevine phenology and growth are delayed due to cooler temperatures VINTAGE recommends a delayed trimming in comparison to the other warmer plots. For such operations, growers usually do not account for spatial variability of grapevine growth, and perform trellising and trimming at the same period for the whole vineyard. As VINTAGE distinguish the plots which are at an earlier development stage from the later plots, it might help the grape growers to better schedule these operations by starting with plot were vegetation is supposed to be more developed, and finish with the later and less developed areas.

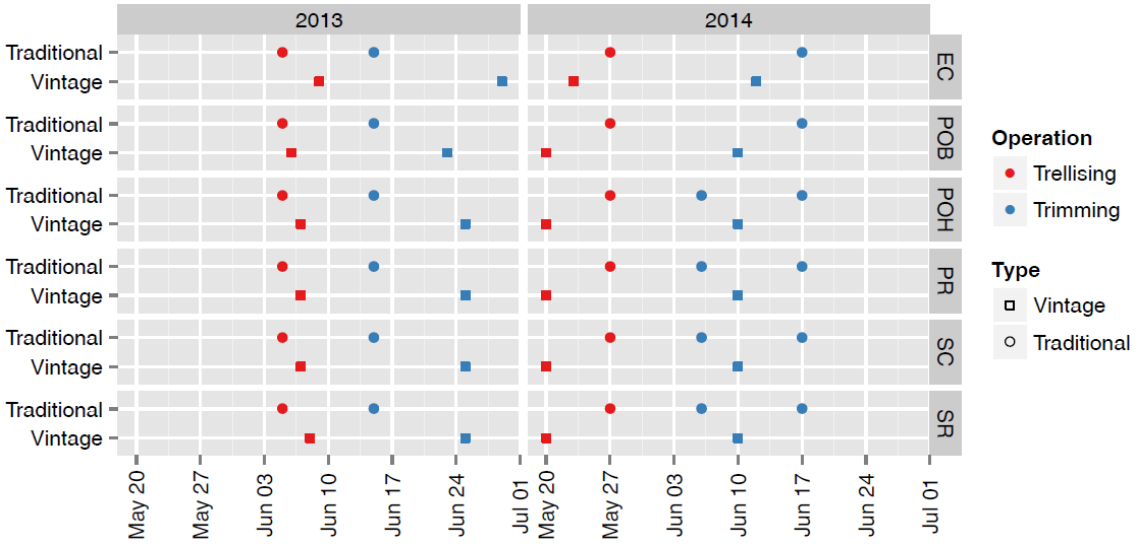


Figure 29: trellising and trimming operations timings in 2013 and 2014. Traditional: field grape growers actual operations; VINTAGE: VINTAGE DSS suggested timing.

Spraying support of VINTAGE

VINTAGE DSS output was tested in pilot #1 (Fontanafredda, Piedmont, Italy) on the Chardonnay variety (San Pietro experimental vineyard) for 2013 and 2014 growing seasons, by comparing the spraying dates and treatment numbers performed by grape growers to DSS recommendations. It has also been tested on pilot #2 (Saint Romain, Burgundy, France) for the 2013 and 2014 growing seasons. Note that for the 2013 season, pilot #2 was not yet active (it has been equipped with WMS during January 2014). 2013 simulations have therefore been performed using data collected from 3 remote weather stations located 6 to 15 km away from Saint Romain winegrowing area, and extrapolated to the pilot area.

		Powdery mildew		Downy Mildew		**All treatments**	
		2013	2014	2013	2014	**2013**	**2014**
Pilot #1 (Fontanafredda, Piedmont, Italy)	Grapegrower (traditional)	8	10	8	10	**16**	**20**
	VINTAGE (traditional)	2	3	4	2	**6**	**5**
	Difference	-6 (-75%)	-7 (-70%)	-4 (-50%)	-8 (-80%)	**-10 (-63%)**	**-15 (-75%)**
Pilot #2 (Saint-Romain, Burgundy, France)	Grapegrower (traditional)	9	9	8	6	**17**	**15**
	VINTAGE (traditional)	2	5	5	5	**7**	**10**
	Difference	-7 (-78%)	-4 (-44%)	-3 (-38%)	-1 (-17%)	**-10 (-59%)**	**-5 (-33%)**
	Grapegrower (organic)	11	9	11	9	**22**	**18**
	VINTAGE (organic)	4	9	6	5	**10**	**14**
	Difference	-7 (-64%)	0 (0%)	-5 (-45%)	-4 (-44%)	**-12 (-55%)**	**-4 (-22%)**

Table 3: total number of treatments against powdery and downy mildews actually performed by grape growers in pilots #1 and #2 as compared to those proposed by the VINTAGE DSS. The difference is VINTAGE – grape grower (divided by grape grower when expressed in percentage).

The numbers and treatments and their timings were compared through timelines in the following figure that provides an example of the spraying timeline for pilot #2, France during the 2014 season.

The figure compares the number of phytosanitary treatments actually performed by the grape-growers to those that would have been done if they had followed the DSS recommendations.

In general, ***VINTAGE suggests a considerable reduction of spraying numbers***.

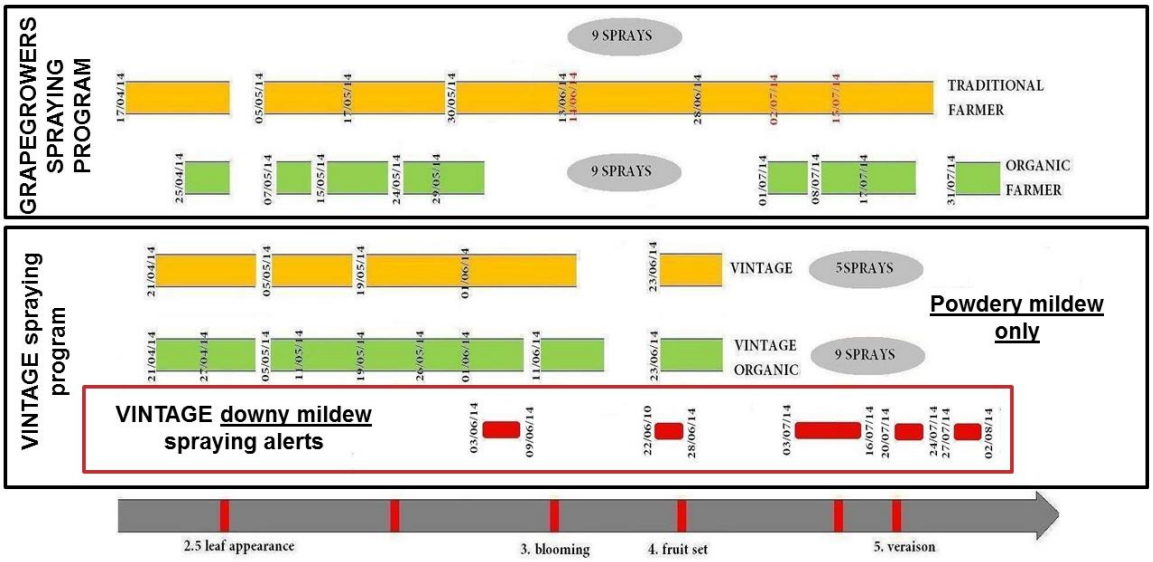


Figure 30: 2014 spraying dates comparison for traditional and organic farming with VINTAGE traditional and organic farming output (in red additional sprays) in pilot #2 (Saint Romain, Burgundy, France).

In Italy (pilot #1), the total number of treatments is reduced from 63 to 75 % of what has actually been performed by the grape growers, while in France, the spraying reduction goes from 22 to 59%. Whether mildews risks have been overestimated by the grape growers or is underestimated by VINTAGE is impossible to know. It needs a real time comparison in the field to evaluate if, when following VINTAGE recommendations, diseases are efficiently controlled. In this case, VINTAGE would provide very large benefits for economics, environmental and sanitary point of views. However, an underestimation of powdery mildews risks in Burgundy by VINTAGE in 2013 is likely: the limited number of treatment (2 for the whole season) for powdery mildew advised by VINTAGE for both traditional and organic farming seems very risky, as usually, grape growers treat much more in Burgundy against this disease (about 8 treatments or more, usually).

Despite some case-specific possible under-evaluation of the disease risks, the pesticide input reduction recommended by the VINTAGE DSS is promising for both economic and environmental aspects. According to La Vigne, a reference paper for grape growers in France (online version available at www.lavigne-mag.fr), in 2012 the mean spending for pest control products by grape growers in Burgundy ranged from 400 €/ha (organic) to 800 €/ha (traditional). Most of these pesticides spending consist in powdery and downy mildew protections products.

Considering the 2014 growing season in France where VINTAGE plant protection strategy seemed consistent to the downy and powdery mildew risks levels reported by grape growers and consultants, VINTAGE DSS protection strategies lead to a reduction of 22% (organic farming) to 33% (traditional farming) of the treatments numbers performed during the season. This reduction correspond to 88 €/ha (organic) and 264 €/ha (traditional) estimated benefits. For a typical 10 ha Burgundy small winery, savings from 880 to 2640 €/year would therefore be reached, plus the additional manpower hours and mechanization costs savings induced by the spraying event reductions. Beyond the economic gain, this bulk analysis suggests a relevant reduction of time consuming interventions during the most intense grape growing period and thus substantial benefits for the vineyard management.

4.1.3.5 Vintage Web Service

The Vintage Web service is the contact point between the technology of the VINTAGE system and its users. In addition to making the implemented models and technologies accessible to the target users through multiple channels including web and mobile interfaces, it also enables the final users to provide feedback and inputs to the VINTAGE system models, so as to improve and calibrate their outputs to adhere more closely with reality.

Being a human interface, contact with end users has been continuous during the course of the project, starting from requirement collection and validation (WP1), continuing to development of mockups leading to early prototypes (WP3), and reaching validation after usability and acceptance testing (WP5). Internal functional testing and validation (WP4) was also performed in parallel as the functionalities were put in place to ensure a satisfactory system responsiveness.

Initial VINTAGE web service activities were carried out by CATTID, who drafter the first user requirements and system requirements for the HMI. Activities have then progressed and reached the completion stage after the entrance of MAVIGEX into the project consortium at M20.

In particular, Mavigex activities started from the interaction with the involved Partners and users to collect feedback on the previously collected user requirements, and progressed with the aim to identify the users of the system, along with their characteristics, as well as defining their requirements expressed in terms of technological expectations. The requirements analysis was accomplished starting from the identified application scenarios, and finalized by means of surveys and direct interviews to the partners involved.

The identified requirements were then used as an input for WP3 activities, focused on the design and development of the HMI and following a **user centric approach** and specific **usability guidelines/heuristics** as stated in the project DoW. In general, a heuristic is a guideline or a general principle that is conceived to drive the design activity and to assess the performed design choices.

In particular, an overall approach entailing five subsequent steps (planes) has been followed. The first two steps (strategy and scope) have been covered by WP1 activities leading to the requirement identification. Building upon these use cases and requirements, WP3 activities have then continued with the next three planes:

- **Structure plane:** functionalities grouping.
- **Skeleton plane:** low-fidelity prototypes (mock-ups) leading to the selection of a horizontal global navigation of a vertical local navigation.
- **Surface plane:** an early HMI prototype was shown at the March 2014 review and used to collect qualitative user feedback.

It is worthwhile noting that Structure and Skeleton plane activities were carried out focusing the interaction on one specific end-user Association (VIGNAIOLI), so as to keep the interaction times low and complete this phase in due time.

Surface plane activities have then progressed iteratively integrating the functionalities provided by the other project partners and involving three SME associations:

BIVB (France): qualitative session in July 2014, hands-on quantitative usability and

acceptance test in November 2014.

VIGNAIOLI (Italy): hands-on quantitative usability and acceptance test in December 2014.

RIOJA (Spain): final HMI hands-on usability and acceptance test in February 2015.

Building upon the full set of user feedback provided during these tests, a **usability analysis** was performed that showed good results, considered in the literature to be close to being "above average". **The overall average SUS score of all 3 quantitative user tests is 66.05**.

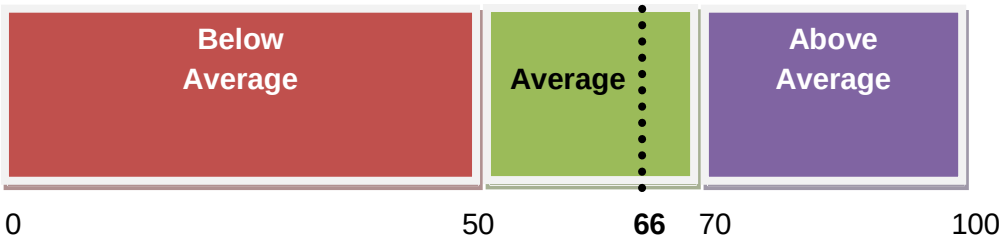


Figure 31: overall average SUS score obtained during test sessions with target users.

In the literature, a result higher than 70 is considered above average, while an average value is considered to be between 50 and 70. The obtained result is thus positioned on the upper end of the average usability values, very close to the above average threshold.

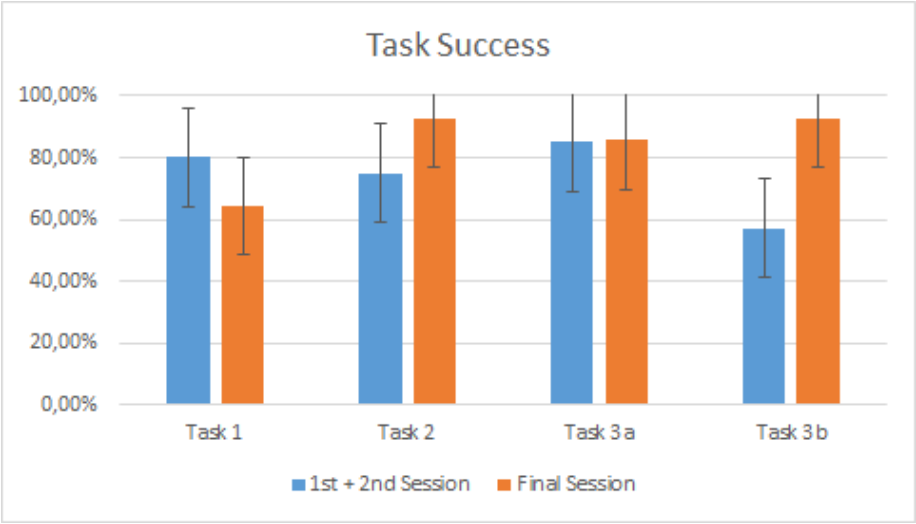


Figure 32: task completion percentage comparison (France + Italy vs. Spain), error bar represents 90% confidence interval. Task 3b not performed in France.

It should be taken into account that this is a measure of stressing the user while using the interface in order to identify weak spots in the design, since in actual realistic conditions there will be an initial training session on the usage of the interface (since this is a professional tool and not a consumer tool). Finally, the mobile version of the web HMI, specifically designed for Apple and Android smartphones and with geo-localization and data insertion functionalities, was designed and implemented. A representative set of screenshots is reported hereafter:

Figure 33: login page - Vineyard view (starting page) - Global navigation menu

One very useful feature that has been developed in the automatic redirect of the VINTAGE HMI based onto the device type. Using the same internet URL (https://gaiag.vintageproject.eu), the system recognizes the device type and automatically redirects the uses to the most suitable user interface, standard web when accessing from a desktop or laptop computer, mobile web when accessing from a smartphone.

The mobile HMI completes and complements the set of user interfaces to cover the foreseen use cases and readying the system for the upcoming pre-commercial and commercial phases to be carried out by the designed partner GAIAG.

Focusing on the progress of the activities partner-wise, they started from the addition of agro-weather models developed by ARPA and from the integration of WMS data provided by LABOR and continued with the addition of remote sensing data from satellites (TU-WIEN and INRA) and with the integration of the DSS module (LABOR). Finally, the mobile interface was developed to complete the coverage of usage cases including also in-field cases.

Regarding the involvement of users in the process, for time and organization reasons at the beginning the user interaction was focused on the VIGNAIOLI (Italy) association to then extend it to BIVB (France) and RIOJA (Spain) associations, involving a total of three SME associations.

Figure following figure summarizes the activity plan that has been followed and completed, specifically highlighting the stakeholders' involvement during the performed phases.

Once reached a functional-complete stage, VINTAGE web services were ready for internal testing, performed within WP4 to ensure the correct integration with the diversified VINTAGE subsystems and a satisfactory response time.

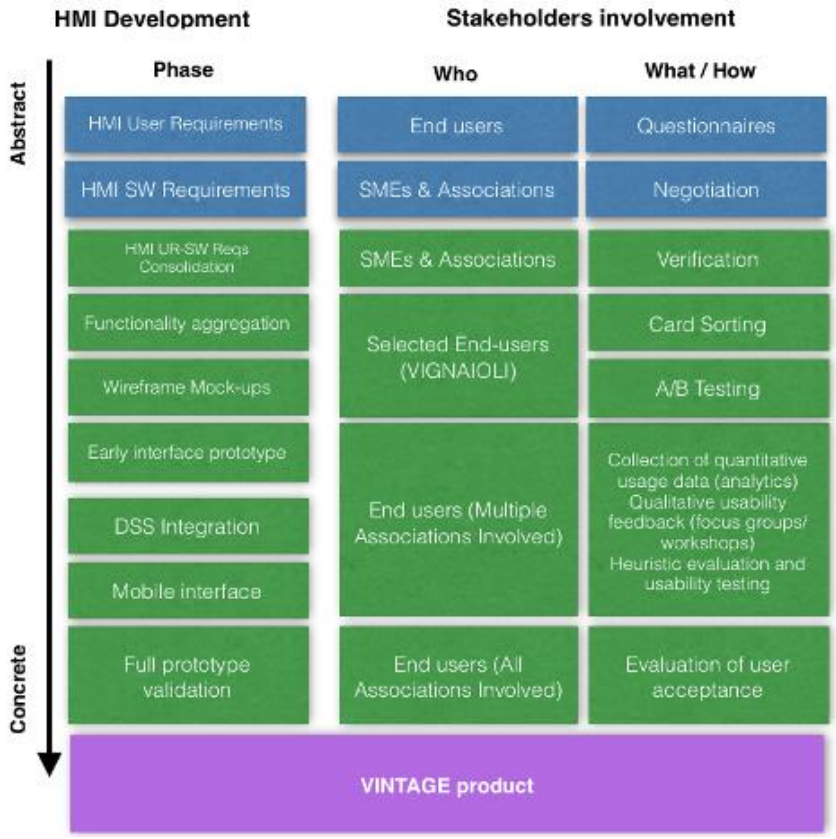


Figure 34: overview of the participative HMI design and implementation activities

Finally, user acceptance was evaluated as a confirmation that the results of the VINTAGE project activities are both relevant and on-target for the target users, paving the way for the future system pre-commercial and commercial exploitation.

Through 3 dedicated user sessions in France, Italy and Spain, VINTAGE system functionalities were evaluated by end users, mostly grape growers and domain experts. Globally, the system is found relevant and usable for grape-growers. Improvements were suggested and implemented during the iterative HMI development process. In addition, further potential developments were suggested by end users and were noted down to serve as a starting point for future developments.

As planned, activities were carried out with a threefold set of tools providing inputs to be processed:

- **Online monitoring of HMI usage**, enabled by the usage of online tracking scripts embedded into the VINTAGE HMI.
- **One-to-one interviews** carried out during the user sessions organized during the second reporting period, when the HMI functional prototype was already available and in an advanced state.
- **Quantitative questionnaires** filled in by the users at the end of the abovementioned user sessions.

As mentioned above, dedicated user sessions have been organized with target users, serving the purposes of both WP3 activities for participative user design, and WP5 activities, so as to optimize the logistic and organization costs and maximize the amount of relevant information collected during

each event.

In particular, the following events have been specifically organized with end-user associations during the second reporting period, where for each session the specific acceptance data collected is reported:

- **July 2014**: user session at BIVB premises in France. Direct oral feedback from participants, one-to-one and one-to-many discussion on system features, with live demonstration. During this early session users have shown interest in the functionalities offered by the system and provided feedback that has been used to refine the design of the HMI (as described in WP3).
- **November 2014**: user session in France during a BIVB meeting. A full quantitative and qualitative session was set-up. Users were invited to perform a set of tasks on the interface and to comment on the ease of use of the interface.
- **December 2014**: user session organized at VIGNAIOLI PIEMONTESI premises in Italy. Quantitative questions filled in by users after performing specific tasks. Dedicated one-to-one interviews were performed with all participants to identify and analyze specific points that interested users also in view of future potential usage.
- **February 2015**: user session at LA RIOJA premises in Spain. Quantitative questions filled in by users after performing specific tasks. Dedicated qualitative questions on system acceptance were answered by the users at the end of the session.

Quantitative Results

Looking at the obtained results, the most significant result comes from the analysis of a selection of answers given to the final questionnaire, from which we can extrapolate some interesting data about the acceptance from the 38 target users that had the opportunity to directly interact with the system in first person.

The above mentioned questionnaire is the **System Usability Scale**, from which we extracted the following 4 questions (2 positive and 2 negative) where the user expresses his/her acceptance to the system:

> **Question 1**: I think that I would like to use this system frequently (positive)
>
> **Question 4**: I think that I would need the support of a technical person to be able to use this system (negative)
>
> **Question 5**: I found the various functions in this system were well integrated (positive)
>
> **Question 10**: I needed to learn a lot of things before I could get going with this system (negative)

These questions had closed answer with scoring between 1 and 5, with questions 4 and 10 being the negative ones. In order to have a coherent look and averaging, results for negative questions have been inverted in the interval 1-5 for questions 4 and 10.

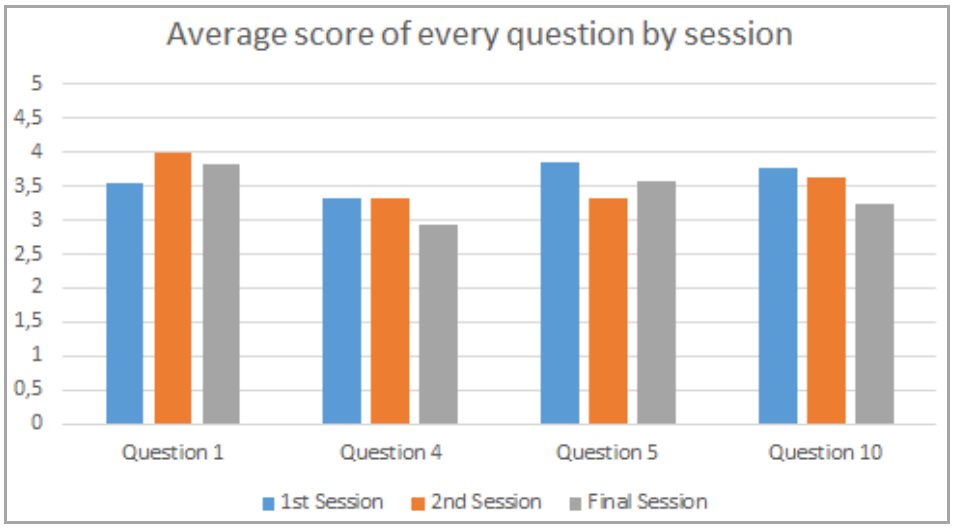


Figure 35: average score of selected quantitative acceptance questions for 38 users for the three performed sessions.

As it can be seen, on average all questions are all above 3, resulting in a positive and promising outcome.

Looking more in depth, the lowest value is for question 5, inquiring on the level of integration between the various functions and functionality of the prototypes. This value could certainly be further improved by specifically addressing the integration and coherence of the different functionalities during the pre-commercial development phase.

Considering instead the highest obtained average value, the corresponding question is question 1, which addresses the potential frequency of use of system functionalities and as such is the question that better expresses the concept of acceptance of the system. With an average value of around 3.8, this allows us to say that the VINTAGE system is very well aligned with the needs of the target users and as such the commercial viability of this product is very promising.

As a final comment, users have suggested the use of an initial introductory training in order to get used and confident in performing the key set of actions. This is a common requirement for professional systems, where upon system activation a presentation and initial training is given to the users, and is therefore aligned with the commercial plan that will be deployed in the post-project phase.

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4.1.4 The potential impact

The production of high-quality wine is one of the leading commercial enterprises in Europe, dominated mainly by SMEs. This market scenario represents the main assumption on which VINTAGE project has been conceived: *"Wine is a cultural and economic asset for Europe and, therefore, a product upon which European countries have built their own fortunes".*

European vine cultivation and wine production, in fact, has a **world dimension** and its target wine sector leads in terms of:

- ✓ **Production**: European vineyards account for approximately 45% of the areas under vines in the world and produces, on average, 60% of world wine production.
- ✓ **Consumption:** the EU accounts for almost 60% of world consumption.
- ✓ **Trade:** the EU is both the leading world exporter and importer.

The EU has more than 2.4 million holdings producing wine, covering 3.6 million hectares, or 2 percent of EU agricultural area and wine makes a considerable contribution to the value of final agricultural output in the majority of the producer Member States (in particular, in **Spain**: 5.4%, Luxemburg: 7,5%, Austria: 6.1%, **Italy**: 9.8%, **France**: 14.3%, **Portugal**: 16.8%).

In despite of this statement, the global competition in this sector has changed to the extent that production of high-quality wine is being challenged by increasing pressure from non-European producers. Specifically, New World producers (mostly South Africa, Australasia and South America) have taken advantage of several compelling market trends in the last years, attacking the European leadership in this sector: the consumers are reported to perceive price/quality ratio as too high for European wines.

In this market context, European vine-growers have focused own interest toward the application of Precision Viticulture technologies in order to re-gain a pivotal role at international level and at this purpose, the **four European Associations of wine producers** involved: Vignaioli Piemontesi (Italy), Grupo De Empresas Vinícolas De Rioja (Spain), Bureau Interprofessionnel des Vins de Bourgogne (France) and Associação Nacional das Denominações de Origem Vitivinícolas (Portugal); **have decided to endorse the VINTAGE project in order to support their associates for increasing their competitiveness**.

In particular, in order to regain competitiveness on the global scenario, European producers must address some unquestionable key factors accounting for the recent success of New World over the Old World:

1. **Wine Quality**: the unreliable and too often irregular quality of Old World wine strives to compete with the very regular quality provided by the New World.
2. **High fragmentation**: the archaic structure of production still in place in the Old World is characterised by small family vineyards or huge cooperatives supported by government subsidies (and traditionally more preoccupied with maintaining low price rather than achieving better quality). In both cases their culture is far from the marketing orientation needed in the modern wine market. New World production is offered by few big companies with high capital and strong marketing orientation.
3. **Expensive production**: high fragmentation and little scale of production does make it difficult for Old World producers to be very profitable: often the costs are too high, allowing no margins to spend on promotion, market research and product development. They must compete with the large scale production of New World, always very cost effective and with large margins to invest in research and promotion.

Nowadays, the number of wineries in Europe is estimated to be 35.000 which represents the initial target market size. Indeed, the VINTAGE Consortium specifically address national markets at first early stage: marketing on a country to country basis will be carried out, targeting four countries (Italy, Spain, France and Portugal) which alone account for more than 50% of world wine production. After this initial phase, the world market will be approached through commercialization channels in USA, Australia, Chile and South Africa.

In additional, it worth to state that based on **EC Regulations** applied in the European viticulture sector, wine consortia needs constant information on their status, production and quality. The EC regulations impose also vineyard growers and wine producers to keep and transmit data for certification to specific new competent **control authorities** according to the UNI EN CEI 45011, COUNCIL REGULATION (EC) No 491/2009 of 25th of May, 2009 amending Regulation (EC) No 1234/2007 *(Es.: Italy: Siquria, Valoritalia, Ismecert, Ceviq s.r.l. etc.; in France: Certipaq, Certisud, Qualisud, etc...)*

We can easily find explicit references to the more stringent **controls** and **annual verifications** carried out by the competent control authority (as referred to in Article 48 of Regulation (EC) No 479/2008) by which the wine producers are forced to respond: for instance, the Council Regulation (EC) No 491/2009 of 25th of May, 2009 amending Regulation (EC) No 234/2007 establishing a common organisation of agricultural markets and on specific provisions for certain agricultural products (Single CMO Regulation).

As a result of new European regulations for wine companies has become critical to rapidly respond to the inspection bodies by the launch of new products on the global market and increasing the quality of the final product. To this scope, **food safety and supply chain management are key factors** that can lead to the production sector in wine at levels avant-garde in the face of competition from new global markets. Wine companies can make better use of their manufacturing

know-how through the adoption of integrated computerized systems such as decision support high value-added services offered by VINTAGE system.

To respond to these needs and to new global competitors**, European wine producers must be able to monitor, detect and store the necessary information** and also to make them available to the proper authorities: consumers and inspection bodies. To this regard, **VINTAGE project aims at providing an IT infrastructure able to register processes and relevant information along the entire vineyard's vegetative phase.**

Indeed, summarizing, modern wine grower faces the following problems:

1. Money

a. High cost of pesticides (both money and environmental impact)

b. High cost of satellite images at high resolution for single wine producers

c. High cost for disease risk

2. Time

a. Time and Inability of wine producers to manage satellite data free of charge

b. Fragmentation of management software used in winery (the producers must enter the same data in different software)

c. Fragmentation of management software used for control authority

d. Difficulty in determining ideal time and intensity of intervention on ripening grapes

e. Difficulty in determining the date of harvest

3. Information

a. Difficult communication between Consortia and users of denomination for controls and annual verifications

b. No information on how to determine ideal time and intensity of intervention on the vegetation (e.x.: precision pruning) for vines vigour control

The following table reporting the main differentiation of VINTAGE system and related advantages as well as economical savings.

Problem	Advantage	Impact cost
Monitoring of ripening grapes, disease risk, intensity of chemical and physical intervention and vegetative growth	Permanent automatic monitoring through a unique interface	Reduction of 25% of man and machine costs

Problem	Advantage	Impact cost
Management and exploitation of information provided by the system	Automatic prescription and mobile version	Reduction of 25% of man and machine costs
Fragmentation of management software used in winery. The producers must enter the same data in different software.	A single interface both for sending data to control authority, Consortia and manage interventions in vineyard	50% time saved
reliability of prescriptions provided to wine makers	Use of holistic approach, monitoring throughout the whole growing cycle, implementing a strong background agronomic.	Reduction of 25% of man and machine costs

Through the differentiation of VINTAGE system, **vine-growers** and **wine producers** are able to:

- **devote different areas in the same vineyard to different quality productions**, as they may differ in vigour, nutrient availability, water status, fruit quality
- **apply spatially-variable management** to even out yield and grape variability (e.g., optimizing fertilizers usage, irrigation, thinning…)
- **react to variability** by managing zones differently and segregating fruit at harvest for unique character “reserve” wines
- **timely discover anomalies**, obtained by the continuous parameter estimation
- **timely react to climate changes** relating issues
- have more information on the **ripeness and quality of grapes**.
- **timely react to risk of fungi or parasites attack**.
- understand and managing the **dynamics of soil, water and phenological stages**
- have **more complete information** during whole phenological cycle
- turn to a **geographical approach** (VS a punctual approach) to reduce final users annual license: one service => many users
- base decisions on solid **interpolation methods and modelling** (with weather forecasts incorporated)
- take advantage of a **user-friendly mobile interface**
- take advantage of a very **high spatial resolution** (10 to 50 meters) system allowing an intra- plot differential management and a more efficient costs reduction
- change to **holistic approach**

4.1.4.1 Route for the exploitation and future commercialization

As mentioned in the previous sections, the Consortium[2] comprises four **European Associations** (VIGNAIOLI, GRUPO RIOJA, BIVB and ANDOVI) grouping several thousands of wine producers, and two **SMEs** (GAIAG and BODEGAS) representing the industrial side: the first one as service and technology provider whilst the second as actual final end user of the new management system implemented. In additional, a group of **RTD Performers** (LABOR, UB-CRC, ARPA, TU-WIEN and INRA), among Universities and Research Centres with specific expertise covering all the technical features required for the development of the VINTAGE platform, has complete the working team.

The overall exploitation strategy is based on previous agreements that GAIAG will act as main technology provider and system administrator of VINTAGE system for the first 2 years after the end of the project (28 February 2015), while Bodegas will act as experimental demonstrator for experiencing VINTAGE system behind the end of the project. This approach will contribute to the development of new software components compliant with end user requirements that the technology provider or system administrator will be able to integrate in future commercial software suites to be released on the EU market when technology would be mature.

To this scope, the goal of the overall exploitation strategy of VINTAGE project is to successfully exploit and commercialize the project results in Europe[3], respecting all the IPRs of all the involved parties, namely: AGs and SMEs, which are the only owners and licensees respectively of new technological and scientific knowledge (**Foreground**).

The **direct target customers/users** of VINTAGE products and services are mainly composed as follow (priority order):

- wine growers associated to AGs partners of Vintage
- AGs partners of Vintage
- wine growers associated to other AGs
- other AGs
- wine growers not associated to any AGs

The **indirect target entities**, which can influence buying decision of direct target users, consists of:

- regional and national authorities engaged in support for the wine sector
- planners/policy makers
- regulatory bodies
- training organizations
- consulting firms

[2] Source: DoW and project web site: vintage-project.eu

[3] Commercialization in the future could possibly include other non-European wine making countries such as US, Australia, South America. and other third countries.

In this view, the VINTAGE offering and **revenue streams** can be distinguish in:

1. **VINTAGE services access** => license to access the web service
2. **wireless monitoring station selling** => named “Vintage WMS” (WMS)
3. **added value services selling** => for example very high resolution satellite maps, drone maps integration
4. **customisation services** (for example integration with other ground sensors).

As system administrator of VINTAGE and on the basis of its skills, GaiaG will manage the following modules: models (phytosanitary, plant growth and soil moisture), satellite data processing and Decision Support System, whilst the other modules will be managed through the establishment or local or international partnerships defined with well-experienced services provider.

Here is an overview of the data flow which is necessary to understand the future operations of VINTAGE in the references market:

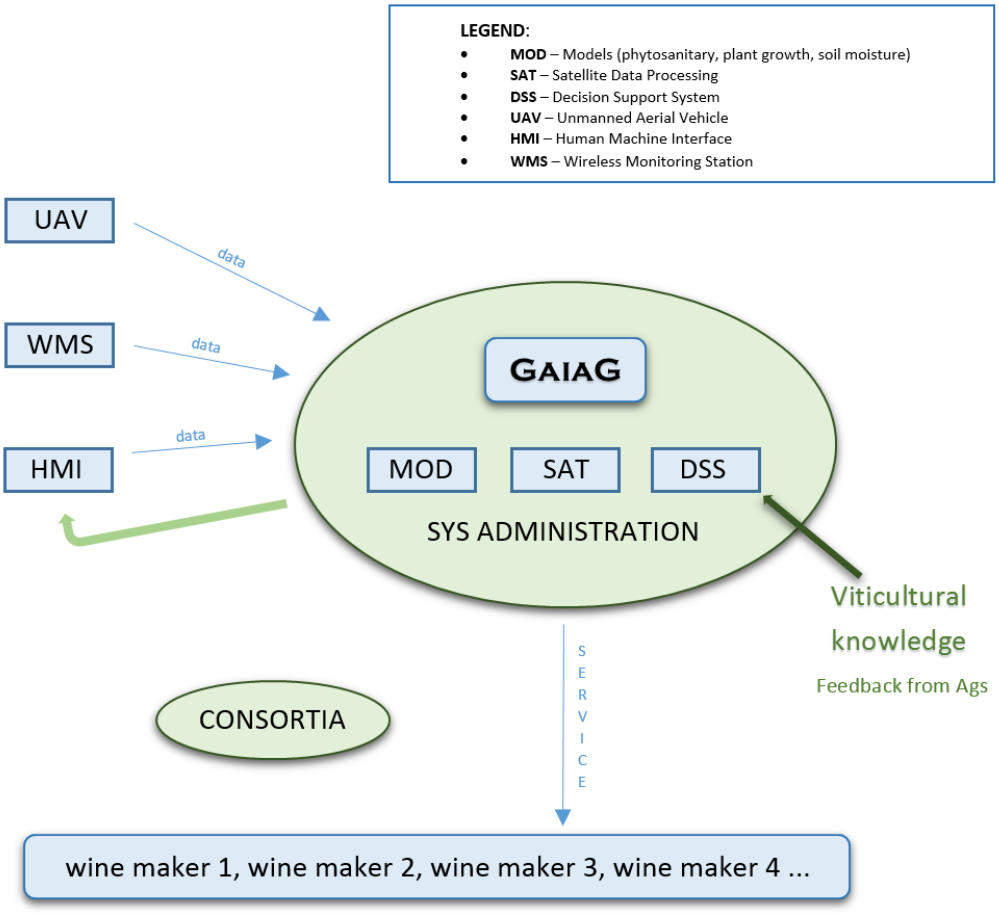

Figure 36: VINTAGE data flow

In this context, it is worth to underline as thanks to e-commerce modules every wine makers will be autonomous in paying the license fee for the VINTAGE web service.

In fact, as shown in the figure above, GAIAG will outsource the update and extensions of Human Machine Interface modules, as well as it will rely to external service providers depending on the

geographic location for Wireless Monitoring Station installation and maintenance. Externalization is the choice also for the optional Added Value Services as very high resolution maps by drone (UAV) or other commercial satellite. All these outsourcing services will be totally transparent to the wine makers; indeed, GAIAG, or more likely the Consortia, will directly manage the contracts with external suppliers, and will integrate the data provided (for example WMS data and drone flight maps).

Drone flight and Very high resolution satellite maps are optional for proper operation of the VINTAGE system and will be at the discretion of the wine makers who wants to increase the accuracy of its output.

The higher economic effort required to final users is given by the cost of the Wireless Monitoring Station installation. This is the main reason why GAIAG intends to lower the start-up costs of VINTAGE system by integrating the ground sensors data from potential suppliers of open, free and already available meteorological stations. To this scope, GAIAG already identified a set of commercial and free metereological data provider or data sources to be contacted right after the end of the project.

Finally, in order to broaden the use of the VINTAGE system, GAIAG intends to establish partnerships with public and private entities related to the wine world at national level. This means that it will not directly contact potential customers but the partners identified at national level will contact the wine producers that they are related to. GAIAG will make available to its sales partners the appropriate promotional tools, such as: website, promotional materials and online demo; with the aim to facilitate the definition of commercial deals.

4.1.4.2 Dissemination and communication strategy

The **dissemination activities were mainly carried out by the AGs and SMEs,** which are deeply involved in the wine sector and, therefore, directly engaged in the promotion of the results towards their associated members as well as partners' network. The main goal of dissemination and communication has been to raise awareness towards the selected target groups about the main activities performed as well as innovations and results achieved during the project. Indeed, the dissemination tasks have been based on full utilization of the results and findings, in order to obtain VINTAGE system's adoption and introduction in the reference market after the end of the project. This type of activities, in fact, represent one of the main key points for a successful project as well as significant tool to pave the way to the future commercialization of the VINTAGE system implemented.

To this regard, whilst the initial period was devoted to disseminate the progress of the project, the development of the first prototype, to specialized target audience, as vine growers, technicians and producers associations, during the final phase, the strategy was focused mainly toward the market and the industrial audiences.

Figure 37: VINTAGE Dissemination Strategy

As shown by the diagram, in the second project phase, the strategy was focused on the market, with a new communication style more product oriented. In fact, the new phase needed a new way to communicate the progress made, the project results and, of course, the VINTAGE final system as product/service. In this context, the updated goal of the dissemination activities have been to *allow and speed up* the market uptake of the results mainly from the SMEs and AGs' side.

The target audience identified for VINTAGE project is composed mostly as follow:

Primary Audiences: **wine growers and Consortia of producers** (end users), regional and national authorities engaged in support for the wine sector.

Secondary Audiences: **planners/policy makers** in federal, provincial and territorial government, regulatory bodies, training organizations.

To this regard, it is worth to highlight as an effective communication required that all material and contents were developed by taking into consideration the needs of the above listed target audiences, and that such material reflects the diversity within each of the stakeholder groups. In fact, the dissemination materials created as well as the main media channels adopted were address to different type and infrastructure made available by each target group.

A detailed list of all the dissemination activities performed during the project is reported in the following table A2, whilst in this context, it is reported briefly the work performed for the design of the main communication means, such as: logo, poster and brochure. In particular, it is worth to remark as the graphical aspect and the background of the web site

Figure 38: VINTAGE project logo

were defined sharing features with the project logo, which was created with the purpose to reinforce the identification of the key elements, distinctive of the project's results.

The logo was included in the design and production of all the dissemination material: website, leaflet, and poster as well as other public and private communication material produced by the Consortium during the project.

Figure 39: VINTAGE brochure and poster

Finally, it is worth to mention as both poster and brochure also include a QR code for an easy connection to the website (www.vintage-project.eu).

4.1.5 The address of the project public website, if applicable as well as relevant contact details.

The VINTAGE web site represents one of the main project asset for the communication as well as the most efficient "window" towards the project stakeholders, end-users and other groups of audience (both academic and industrial) operating in the specific domain of the precision viticulture and, therefore, interested in the technical solutions proposed. Indeed, one of the goal during its design phase was the definition of the "**key messages"** to be disseminated and the **"way"** to communicate them towards a well target set of external audience.

In particular, the Consortium devoted particular attention on the "receiving" (end users perspective), what they need to know about the project and how the messages should be communicated in order to assure a relevant level of impact among the targeted groups of interest identified and, therefore, to reach a satisfying quality's level of results.

The VINTAGE project web page was designed through the RIOJA's coordination with the contributions and periodic updates provided by all the other partners and related to the project's purposes and objectives, its innovations and main benefits ass well as the most relevant news and findings, events and other communications activities.

The domain was registered at the following web-address: www.vintage-project.eu.

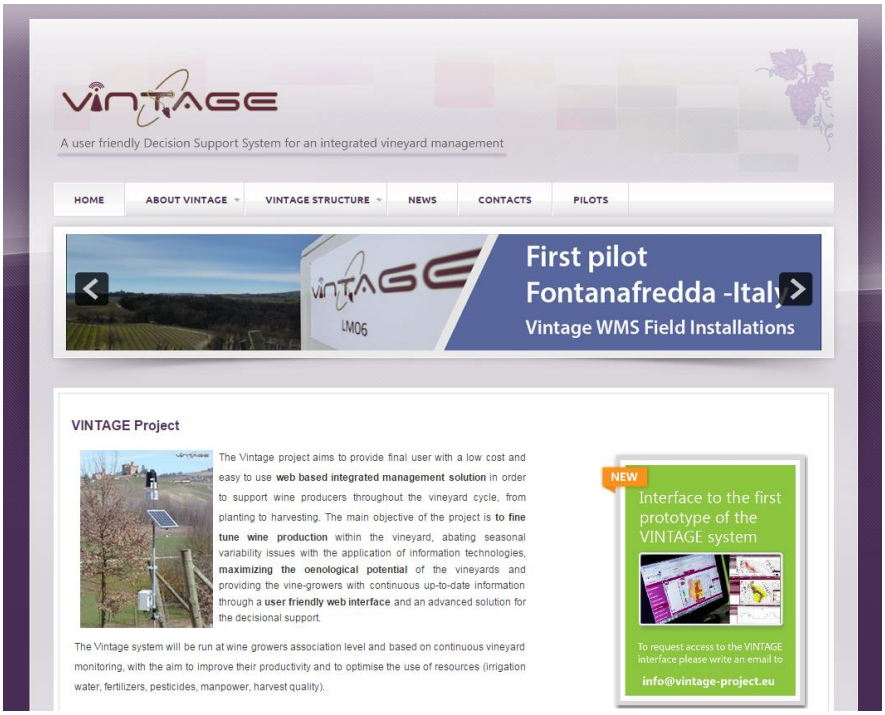

Figure 40: VINTAGE web site – Home Page[4]

The layout of the several web pages was studied with the purpose to create a screenshot that uniquely identifies the project, and designed on the basis of a simple and clear structure with the aim of facilitating users' access to the information and main news.

[4] The Home page of the official project web site reports the FP7 and the European flag logos together the following sentence established in accordance to the Art. 30 of the Annex II to the Grant Agreement and relative Article 8.6 of the Consortium Agreement):

"The research leading to these results has received funding from the European Union's Seventh Framework Programme managed by REA - Research Executive Agency, FP7/2007-2013 under Grant Agreement no.286608".

However, significant updates and improvements were provided during the last period in order to increase the communication impact mainly towards an industrial target groups. In particular, the slider of the main menu showed four banner dedicated to the pilot's installations performed during the project, and for each of them the following information are reported:

- ✓ the vineyard map
- ✓ the site inspection
- ✓ the installation phase
- ✓ the maintenance operation

Figure 41: VINTAGE web site – Homepage slider

In additional, a specific link to the interface of VINTAGE system prototype was also integrated and made available through the home page: interested users that have requested access can go through the link of the banner placed in the right column and can see how Vintage system work.

Figure 42: VINTAGE web site – link to the prototype interface

4.2 Use and dissemination of foreground

This section consists of:

- **Section A**

  This section describes the dissemination measures, including any scientific publications relating to foreground.

- **Section B**

  This section specifies the exploitable foreground and provides the plans for exploitation. All these data can be public or confidential; the report clearly marks non-publishable (confidential) parts that will be treated as such by the Commission. Information under Section B that is not marked as confidential can be made available in the public domain thus demonstrating the added-value and positive impact of the project on the European Union.

Section A (public)

This section includes two templates

Template A1: List of all scientific (peer reviewed) publications relating to the foreground of the project.

Template A2: List of all dissemination activities (publications, conferences, workshops, web sites/applications, press releases, flyers, articles published in the popular press, videos, media briefings, presentations, exhibitions, thesis, interviews, films, TV clips, posters).

TEMPLATE A1: LIST OF SCIENTIFIC (PEER REVIEWED) PUBLICATIONS, STARTING WITH THE MOST IMPORTANT ONES										
NO.	Title	Main author	Title of the periodical or the series	Number, date or frequency	Publisher	Place of publication	Year of publication	Relevant pages	Permanent identifiers[5] (if available)	Is/Will open access[6] provided to this publication?

[5] A permanent identifier should be a persistent link to the published version full text if open access or abstract if article is pay per view) or to the final manuscript accepted for publication (link to article in repository).

[6] Open Access is defined as free of charge access for anyone via Internet. Please answer "yes" if the open access to the publication is already established and also if the embargo period for open access is not yet over but you intend to establish open access afterwards.

TEMPLATE A2: LIST OF DISSEMINATION ACTIVITIES								
NO.	Type of activities[7]	Main leader	Title	Date/Period	Place	Type of audience[8]	Size of audience	Countries addressed
1	Meeting	Rioja	Technical Committee of the Federación Española del Vino	March, 12th. 2012	Jerez de la Frontera	Operators of viticolture and enology, producers,	14	Spain
2	Meeting	Rioja	Technical Commission of the D.O.Ca. Rioja Consejo Regulador	June, 13th. 2012	Logroño (La Rioja)	Operators of viticolture and enology, producers	16	Spain
3	Seminar	ANDOVI	ANDOVI's National Congress	27 June 2012	Porto (PT)	Wine companies, winemakers, grape growers and policy makers	-	Portugal
4	newsletter	ANDOVI	Vintage project general meeting	27 July 2012	ANDOVI's Boletim informative (newsletter)	Operators of viticolture and enology, producers		Portugal
5	Workshop	VIGNAIOLI PIEMONTESI	First internal Training Workshop	30 October 2012	Alba, Piedmont (IT)	Operators of viticolture and enology, producers,	-	Italy
6	Meeting	Rioja	Board of Directors of the PTV (Spanish Technological	30 October 2012	Madrid.	Operators of viticolture and enology, producers		Spain

[7] A drop down list allows choosing the dissemination activity: publications, conferences, workshops, web, press releases, flyers, articles published in the popular press, videos, media briefings, presentations, exhibitions, thesis, interviews, films, TV clips, posters, Other.

[8] A drop down list allows choosing the type of public: Scientific Community (higher education, Research), Industry, Civil Society, Policy makers, Medias, Other ('multiple choices' is possible).

TEMPLATE A2: LIST OF DISSEMINATION ACTIVITIES								
NO.	Type of activities[7]	Main leader	Title	Date/Period	Place	Type of audience[8]	Size of audience	Countries addressed
			Wine Platform).					
7	Newsletter n°892	BIVIB	VINTAGE : les outils d'avenir de la viticulture	01 February 2013	BIVIB infos https://extranet.bivb.com/newsletter/n-892,322,6869.html?gabarit=newsletter&xtor=EPR-264	Researchers, Wine companies, winemakers, grape growers and policy makers		France
8	Newsletter n°894	BIVIB	Projet VINTAGE: vignes et outils informatiques faites-nous part de vos habitudes d'utilisation !	15 February 2013	BIVIB infos https://extranet.bivb.com/newsletter/n-894,322,6894.html?gabarit=newsletter&xtor=EPR-266	Researchers, Wine companies, winemakers, grape growers and policy makers		France
9	Press-release	ANDOVI	On-line promotion	01 February 2013	Websites	Wine companies, winemakers, grape growers and policy makers	-	Portugal
10	Press-release	Rioja	Media pubblication	27/02/2013	INVESTIGACION VIÑEDO	Operators of viticolture and enology, producers,		Spain
11	Press-release	Rioja	Grupo Rioja parcetipa en un Proyecto europeo para la calidad de la uva	27/02/2013	Finanzas.com	Operators of viticolture and enology, producers,		Spain
12	Newspaper article	Rioja	Grupo Rioja en la gestiòn integral del vinedo	28/02/2013	Diario de la Rioja	All public		Spain
13	Newspaper article	Rioja	Grupo Rioja	28/02/2013	La Rioja	All public		Spain

TEMPLATE A2: LIST OF DISSEMINATION ACTIVITIES								
NO.	Type of activities[7]	Main leader	Title	Date/Period	Place	Type of audience[8]	Size of audience	Countries addressed
			parcetipa en un Proyecto europeo para la calidad de la uva					
14	national wine exhibition	Rioja	FEVINO. Ferrol Wine Fair	12 March 2013	Ferrol (Galicia).	Operators of viticolture and enology, producers, wine lovers, journalists,		Spain
15	Presentation of Vintage Project	VIGNAIOLI PIEMONTESI	Prowine 2013	24 March 2013	Dusseldorf (GE)	Operators of viticolture and enology, producers, wine lovers, journalists, trade	200	Worldwide
16	Meetings	ANDOVI	Technical meeting regional director	01 April 2013	Porto (PT)	Tecnhical Directos of Wine Regions	10	Portugal
17	international wine exhibition	Vignaioli Piemontesi	- Vinitaly 2013 :	07 April 2013	Verona (I)	Operators of viticolture and enology, producers, wine lovers, journalists, trade	200	Worldwide
18	Poster	TU Wien	European Geosciences Union General Assembly 2014. http://meetingorganizer.copernicus.org/EGU2014/EGU2014-2759-1.pdf	27 April 2013	Wien	Researchers, Users and Developers of Earth Observations from Satellites	500	Europe

TEMPLATE A2: LIST OF DISSEMINATION ACTIVITIES								
NO.	Type of activities[7]	Main leader	Title	Date/Period	Place	Type of audience[8]	Size of audience	Countries addressed
19	Paper, poster	ARPA-ER	XVI AIAM Vintage: sviluppo di un sistema complesso di assistenza alla viticoltura	4-6 June 2013	Florence, Italy	Researchers, Agro-meteorologists	80	Worldwide
20	Paper, poster	ARPA-ER	XVI AIAM An integrated model for phenological development and growth of grapevine (Vitis vinifera L.)	4-6 June 2013	Florence, Italy	Researchers, Agro-meteorologists	80	Worldwide
21	International wine exhibition	VIGNAIOLI PIEMONTESI	Vinexpo 2013	16 June 2013	Bordeaux (FR)	Operators of viticolture and enology, producers, wine lovers, journalists	150	Worldwide
22	Symposium	TU WIEN, ARPA-ER	Integration of Remote Sensing in a Decision Support System for Vineyard Management	09 September 2013	Edinburgh (GB)	Scientists, agronomists and wine-growers	200	Worldwide

TEMPLATE A2: LIST OF DISSEMINATION ACTIVITIES								
NO.	Type of activities[7]	Main leader	Title	Date/Period	Place	Type of audience[8]	Size of audience	Countries addressed
23	Symposium	TU WIEN	The Potential of High Resolution Soil Moisture from Active Microwave Remote Sensing for Supporting Precision Viticulture	09 September 2013	Edinburgh (GB)	Researchers, Users and Developers of Earth Observations from Satellites	120	Europe
24	International wine exhibition	VIGNAIOLI PIEMONTESI	ENOVITIS 2013	4 November 2013	Milano (I)	Operators of viticolture and enology, producers, wine lovers, journalists.	-	Worldwide
25	Web site	BIVB	Projet VINTAGE : six stations météorologiques implantées sur l'AOC Saint-Romain (Bourgogne)	18 January 2014	http://www.vins-et-oenotourisme.fr/journal-du-vin/projet-vintage--six-stations-meteorologiques-implantees-sur-l-aoc-saint-romain--bourgogne---231.html	all public, amateur wine	-	France
26	Web site	BIVB	Projet VINTAGE : six stations météorologiques implantées sur l'AOC Saint-Romain (Bourgogne)	18 January 2014	http://www.vins-et-oenotourisme.fr/journal-du-vin/projet-vintage--six-stations-meteorologiques-implantees-sur-l-aoc-saint-romain--bourgogne---231.html	all public, amateur wine	-	France

TEMPLATE A2: LIST OF DISSEMINATION ACTIVITIES								
NO.	Type of activities[7]	Main leader	Title	Date/Period	Place	Type of audience[8]	Size of audience	Countries addressed
27	Web site	BIVB	La viticulture bourguignonne de demain	21 January 2014	http://www.mybettanedesseauve.fr/la-viticulture-bourguignonnede-demain	all public	40.000	France
28	Web site	BIVB	La viticulture bourguignonne de demain	21 January 2014	http://www.mybettanedesseauve.fr/la-viticulture-bourguignonnede-demain	all public	40.000	France
29	TV interview	BIVB	12/13 Midi pile Bourgogne - 30/01/2014 12:09:10	30 January, 2014	FRANCE 3 BOURGOGNE	all public	80.000	France
30	TV interview	BIVB	12/13 Midi pile Bourgogne - 30/01/2014 12:09:10	30 January 2014	FRANCE 3 BOURGOGNE	all public	80.000	France
31	Web site	BIVB	Vintage en Bourgogne	31 January 2014	http://www.gaultmillau.fr/actualites/vins/vintage-en-bourgogne-710	all public	-	Europe
32	Press release, French	BIVB	Vintage : la Bourgogne partenaire d'un outil d'avenir	31 January 2014	http://www.lejsl.com/actualite/2014/01/30/vintage-la-bourgogne-partenaire-d-un-outil-d-avenir	all public	450.000	France
33	Web site	BIVB	Bourgogne : L'AOC Saint-Romain expérimente le big data parcellaire	31 January 2014	http://www.lavigne-mag.fr/actualites/bourgogne-l-aoc-saint-romain-experimente-le-big-data-parcellaire-83684.html	all public	8.383	Europe
34	Press release, French	BIVB	Vintage : la Bourgogne	31 January 2014	http://www.lejsl.com/actualite/2014/01/30/vintage-la-	all public	450.000	France

TEMPLATE A2: LIST OF DISSEMINATION ACTIVITIES								
NO.	Type of activities[7]	Main leader	Title	Date/Period	Place	Type of audience[8]	Size of audience	Countries addressed
			partenaire d'un outil d'avenir		bourgogne-partenaire-d-un-outil-d-avenir			
35	TV interview	BIVB	19/20 Edition régionale Bourgogne - 01/02/2014 19:06:24	01 February 2014	FRANCE 3 BOURGOGNE	all public	-	France
36	Press release, French	UB-CRC	la meteo pour les vignerons	03 February 2014	http://www.bienpublic.com/edition-de-beaune/2014/02/03/la-meteo-pour-les-vignerons	all public	-	France
37	Press release, French	BIVB	la meteo pour les vignerons	03 February 2014	http://www.bienpublic.com/edition-de-beaune/2014/02/03/la-meteo-pour-les-vignerons	all public	-	France
38	Web site	BIVB	Saint-Romain : la météo pour les vignerons	03 February 2014	http://www.bienpublic.com/edition-de-beaune/2014/02/03/la-meteo-pour-les-vignerons	all public	350.000	Europe
39	Press release, French	BIVB	La météo pour les vignerons	03 February 2014	LE BIEN PUBLIC LES DEPECHES	all public	46.446	France
40	Radio Interview	BIVB	JOURNAL RÉGIONAL DE 7H00 - 03/02/2014 07:05:03	03 February 2014	FRANCE BLEU BOURGOGNE	all public	-	France
41	Wine exibihition	Vignaioli Piemontesi	Prodexpo 2014	10 February 2014	Moscow (RU)	Operators of viticolture and enology, producers,	-	worldwide

TEMPLATE A2: LIST OF DISSEMINATION ACTIVITIES								
NO.	Type of activities[7]	Main leader	Title	Date/Period	Place	Type of audience[8]	Size of audience	Countries addressed
						wine lovers, journalists, trade		
42	Press release, French	BIVB	Le programme Vintage dans sa phase d'application	10 February 2014	VSB VINS SPIRITUEUX BOISSONS		-	France
43	Press release, French web site	BIVB	Les big data en direct des vignes	11 February 2014	L'EXPLOITANT AGRICOLE DE SAONE ET LOIRE	Journal professionnel hebdomadaire. Information agricole / viticole	-	France
44	Press release, French web site	BIVB	Des nuages de données pour les Climats	19 February 2014	TERRES DE BOURGOGNE	Magazine hebdomadaire professionnel de la région Bourgogne	-	France
45	Press release, French	BIVB	Viticulture durable : le programme vintage est entre dans sa phase d'application	20 February 2014	EN DIRECT LES VINS DE BOURGOGNE EN DIRECT	grape experts	-	France
46	Press release, French	BIVB	Vintage en application en Bourgogne	20 February 2014	LA MARNE AGRICOLE		-	France
47	Wine exhibition	Vignaioli Piemontesi	Prowine 2014 : international wine exhibition	23 March 2014	Dusseldorf (D)	Operators of viticolture and enology, producers, wine lovers,	200	Worldwide

TEMPLATE A2: LIST OF DISSEMINATION ACTIVITIES								
NO.	Type of activities[7]	Main leader	Title	Date/Period	Place	Type of audience[8]	Size of audience	Countries addressed
						journalists, trade		
48	Wine exhibition	Vignaioli Piemontesi	Vinitaly 2014 : international wine exhibition	06/04/2014	Verona (I)	Operators of viticolture and enology, producers, wine lovers, journalists, trade	250	Worldwide
49	Conference	ANDOVI	ANDOVI General Meetting	21 April 2014	Funchal, Portugal	Presidents of Wine Regions/Technicians of Madeira Wine Region	20	Portugal
50	Workshops	ANDOVI	Presentation of Vintage Project	1 May 2014	Lisbon	Tecnhicians of Grapes Growers associations	-	Portugal
51	Personal Contact (Portuguese)	ANDOVI	ANDOVI meeting	01 August 2014	Oporto, Regua, Lisboa, Evora, Viseu	Presidents of Wine Regions	4	Portugal
52	Conference	ARPA-ER	Festival of Agriculture Regional	7 March 2014	Faenza (IT)	grape growers	-	Italy
53	Press release, French	BIVB	À quand une agrométéo de précision	23 April 2014	REUSSIR VIGNE -	revue mensuelle d'informations agricoles spécialisée dans la vigne et le vin	-	France
54	Press release, French	BIVB	À quand une agrométéo de	23 April 2014	L'UNION DU CANTAL	Anciennement intitulé, L'Union	-	Europe

TEMPLATE A2: LIST OF DISSEMINATION ACTIVITIES								
NO.	Type of activities[7]	Main leader	Title	Date/Period	Place	Type of audience[8]	Size of audience	Countries addressed
			précision			Agricole et Rurale.		
55	Conference	TU WIEN	Optimisation of Global Grids for High-Resolution Remote Sensing Data	27 April 2014	Wien	Researchers, Users and Developers of Earth Observations from Satellites	500	Worldwide
56	Paper, presentation	ARPA-ER	XVII AIAM Modelli agrometeorologici ad alta risoluzione a supporto della viticoltura di precisione	10-12 June 2014	Rome (IT)	Researchers, Agro-meteorologists	80	Worldwide
57		BIVB	Viticulture durable - Le projet européen Vintage progresse	11 June 2014	LA JOURNEE VINICOLE	All public		
58	Press release, French	BIVB	Quand la météo joue avec Bacchus	07 July 2014	http://experimentarium.u-bourgogne.fr/blog/index.php/2014/07/07/quand-la-meteo-joue-avec-bacchus/	all public	-	France
59	Workshop, power point, French	BIVB	Réunion de démonstration de l'interface en ligne VINTAGE	23 July 2014	Saint Romain, Burgundy, France	grape growers	12	France

TEMPLATE A2: LIST OF DISSEMINATION ACTIVITIES								
NO.	Type of activities[7]	Main leader	Title	Date/Period	Place	Type of audience[8]	Size of audience	Countries addressed
60	pubblication	LABOR	Vintage project	25 july 2014	http://cordis.europa.eu/project/rcn/101471_en.html	Researchers, consultants, industries, agricultural operators	-	Europe
61	Press release, French	INRA /UB-CRC	Un drone au dessus des climats	12 August 2014	http://www.bienpublic.com/edition-cote-de-beaune/2014/08/12/un-drone-au-dessus-des-climats	all public	-	France
62	Press release, French	BIVB	Un drone au dessus des climats	12 August 2014	http://www.bienpublic.com/edition-cote-de-beaune/2014/08/12/un-drone-au-dessus-des-climats	all public	-	Europe
63	Workshop, power point, Italian	ARPA-ER	Riunione di dimostrazione dell'interfaccia online Vintage	28 August 2014	Bologna, Italy	grape growers	7	Italy
64	Press release, French	UB-CRC	nuit des chercheurs	26 September 2014	http://www.dijonbeaunemag.fr/chercheurs-la-nuit-de-tous-les-possibles/	all public	-	France
65	Radio interview, French	UB-CRC	nuit des chercheurs/radio campus Dijon	26 September 2014	http://dijon.radio-campus.org/campus-en-direct-de-la-nuit-europeenne-des-chercheurs/	all public	-	France
66	Workshop, power point, French	UB-CRC	Nuit des chercheurs	26 September 2014	Dijon, Burgundy, France	all public	100	France

TEMPLATE A2: LIST OF DISSEMINATION ACTIVITIES								
NO.	Type of activities[7]	Main leader	Title	Date/Period	Place	Type of audience[8]	Size of audience	Countries addressed
67	Workshop, French	UB-CRC	Les grand rendez-vous techniques de Bourgogne	04 November 2014	Beaune, Burgundy, France	grape experts	13	France
68	Conference, French	UB-CRC	Les grand rendez-vous techniques de Bourgogne	04 November 2014	Beaune, Burgundy, France	grape growers, technicians, grape experts	300	France
69	Paper	UB-CRC	27th World Congress of Vine and Wine :GIS, mechanistic modelling and ontology: a performing mix for precision and sustainable viticulture	09 November 2014	Mendoza,Argentina	researchers, grape experts, grape growers	-	Worldwide
70	Conference	UB-CRC	27th World Congress of Vine and Wine	09 November 2014	Mendoza, Argentina	researchers, grape experts, grape growers	600	Worldwide
71	Workshop, power point, French	UB-CRC	Vintage presentation to the Regional Group of Experiments in Viticulture (GREV)	15 January 2015	Chablis, Burgundy, France	grape experts	20	France
72	Workshop, power point, French	UB-CRC	Vintage presentation to the Regional Group of Experiments in Viticulture (GREV)	23 January 2015	Arbois, Jura, France	grape experts	15	France

TEMPLATE A2: LIST OF DISSEMINATION ACTIVITIES								
NO.	Type of activities[7]	Main leader	Title	Date/Period	Place	Type of audience[8]	Size of audience	Countries addressed
73	Newspaper article	Rioja	Las bodegas Riojanas conoceran el Proyecto vintage en un ajornada tecnica	22 February 2015	Newspaper 20minutos	All public	-	Spain
74	Newspaper article	Rioja	Las bodegas Riojanas conoceran el Proyecto vintage en un ajornada tecnica	22 February 2015	Teinteresa.es	All public	-	Spain
75	Newspaper article	Rioja	Las bodegas Riojanas conoceran el Proyecto vintage en un ajornada tecnica	22 February 2015	Newspaper Gente - digital	All public	-	Spain
76	Newspaper article	Rioja	Las bodegas Riojanas conoceran el Proyecto vintage en un ajornada tecnica	22 February 2015	Newspaper La Vanguardia	All public	-	Spain
77	Newspaper article	Rioja	Unos sensores en los vinedos mejoraran la eficacia del cultivos	22 February 2015	Revista Alimentaria	All public	-	Spain

TEMPLATE A2: LIST OF DISSEMINATION ACTIVITIES								
NO.	Type of activities[7]	Main leader	Title	Date/Period	Place	Type of audience[8]	Size of audience	Countries addressed
78	Newspaper article	Rioja	Las bodegas Riojanas conoceran el Proyecto vintage en un ajornada tecnica	22 February 2015	Newspaper El Economista	All public	-	Spain
79	Conference	Rioja	Presentación de los resultados del Proyecto Europeo VINTAGE	24 February 2015	Logroño (E)	researchers, grape experts, grape growers	-	Spain
80	Interview	Rioja	Entrevista a José Luis Benítez: Informativo 20.00h. Entrevista a José Luis Benítez: Informativo 07.20h. 25-02-2015		Radio RIOJA – cadena ser	All public		
81	Newspaper article	Rioja	Crean una herramienta tecnológica que permite la "viticultura de precisión	24 February 2015	Newspaper EFE	All public	-	Spain
82	Newspaper article	Rioja	Crean una herramienta tecnológica que permite la	24 February 2015	Newspaper Inversion Finanzas	All public	-	Spain

TEMPLATE A2: LIST OF DISSEMINATION ACTIVITIES								
NO.	Type of activities[7]	Main leader	Title	Date/Period	Place	Type of audience[8]	Size of audience	Countries addressed
			"viticultura de precisión					
83	Newspaper article	Rioja	El grupo Rioja da a conocer el Proyecto vintage	26 February 2015	La Rioja	All public	-	Spain

Section B (Confidential[9] or public: confidential information to be marked clearly)

Part B1

The **applications for patents, trademarks, registered designs**, etc. are listed according to the template B1 provided hereafter.

TEMPLATE B1: LIST OF APPLICATIONS FOR PATENTS, TRADEMARKS, REGISTERED DESIGNS, ETC.					
Type of IP Rights[10]:	Confidential	Foreseen embargo date	Application reference(s) (e.g. EP123456)	Subject or title of application	Applicant (s) (as on the application)

[9] Note to be confused with the "EU CONFIDENTIAL" classification for some security research projects.

[10] A drop down list allows choosing the type of IP rights: Patents, Trademarks, Registered designs, Utility models, Others.

Part B2

The project foreground is listed according to the template B2 provided hereafter.

TEMPLATE B2: LIST OF FOREGROUND								
Type of Exploitable Foreground[11]	Description of exploitable foreground	Confidential	Foreseen embargo date	Exploitable product(s) or measure(s)	Sector(s) of application[12]	Timetable, commercial or any other use	Patents or other IPR exploitation (licences)	Owner & Other Beneficiary(s) involved
Commercial exploitation of R&D results	VINTAGE universal electronic board (VUB), including the production of customised main and local monitoring stations.	YES	-	VINTAGE WMS	Viticulture sector, and more in general any agricultural domain.	2015	A potential patent for electronic board will be assessed.	AG partners are co-owners of the result, whilst Bodegas has the right for an unlimited use of the pilot installed. GAIAG has the right to exploit the result commercially for the first two year after the end of project and to license to Third Party its manufacturing and/or installation and maintenance services.
Commercial exploitation of R&D results	Advanced expert system aimed at supporting	YES	-	VINTAGE decision support system engine	Viticulture sector	2016	No patent application is foreseen for this result.	AG partners are co-owners of the result, whilst Bodegas has the

[19] A drop down list allows choosing the type of foreground: General advancement of knowledge, Commercial exploitation of R&D results, Exploitation of R&D results via standards, exploitation of results through EU policies, exploitation of results through (social) innovation.

[12] A drop down list allows choosing the type sector (NACE nomenclature): http://ec.europa.eu/competition/mergers/cases/index/nace_all.html

TEMPLATE B2: LIST OF FOREGROUND								
Type of Exploitable Foreground[11]	Description of exploitable foreground	Confidential	Foreseen embargo date	Exploitable product(s) or measure(s)	Sector(s) of application[12]	Timetable, commercial or any other use	Patents or other IPR exploitation (licences)	Owner & Other Beneficiary(s) involved
	decision-makers in taking appropriate and effective decisions based on current status in field and best practices.			and models. This result is paired to the VINTAGE web service from a commercial perspective.				right for an unlimited free use of DSS. GAIAG, as system administrator, will be in charge of the maintenance and the potential upgrades of the DSS.
Commercial exploitation of R&D results	VINTAGE web service	YES	-	VINTAGE Platform. This result is paired to the VINTAGE DSS from a commercial perspective.	Viticulture sector, and more in general any agricultural domain.	2016-2017	A method (process) patent may be applied in the next years.	AG partners are co-owners of the result, whilst Bodegas has the right for a free use of platform. GAIAG, as system administrator, or its subcontractors, will be in charge of the maintenance and the potential upgrades of the platform. It will also have the right to commercially exploit the platform in Italy for two years after the end of project as well as to assess further

TEMPLATE B2: LIST OF FOREGROUND								
Type of Exploitable Foreground[11]	Description of exploitable foreground	Confidential	Foreseen embargo date	Exploitable product(s) or measure(s)	Sector(s) of application[12]	Timetable, commercial or any other use	Patents or other IPR exploitation (licences)	Owner & Other Beneficiary(s) involved
								application domains.

1. Wireless Monitoring Station

The hardware development tasks consisted of the development, construction and installation of the Wireless Monitoring Stations (**WMS**). These stations, after a measurement cycle, send to a central server a data packet, via wireless interface, containing the status of the *agrimet* (agricultural-meteor ological) *variables* (readings of agrimet related quantities).

The software interface, installed on the central server, takes these data packets and use them for the models calculations and data interpolations. The data can also be used directly by the Decision Support System (DSS).

The WMS net, installed in (or around) the vineyard, is composed by an appropriate number of stations which, for reasons concerning data models, fall in two main categories:

I. **Main stations**: used for models calculations

II. **Local stations**: used for transects interpolations

Each station is composed by an electronic circuit (**VUB**, VINTAGE Universal Board) that manages all the operations of **sensor interfacing** and **wireless communication**. Moreover, an upgraded version of the VINTAGE electronic board taking care of power supply, data logging and telecommunication was also designed and is being developed. Finally, system failure management and security issues are also addressed.

The foreground will be exploited immediately at the end of the project to:

- install new WMS useful to exploit the Vintage system in new areas;
- integrate and, if necessary change, the settings/equipment of existing other ground stations;

- based on the standards and methods defined in Vintage, collect agricultural-meteorological data from monitoring station already existing.

AG partners are co-owners of the result, whilst Bodegas has the right for an unlimited use of the pilot installed. GAIAG, or its subcontractors, as the right to exploit the Wireless Monitoring Station installation for the first 2 years after the end of the project:

a. the new wineries will deploy the monitoring stations for the initial roll out of the system and will purchase additional stations from GAIAG or its licensees
b. GAIAG will have the exclusive right to manufacture and/or license the manufacturing of the new Wireless Monitoring Stations to third parties for the first two years after the project completion.

2. Decision Support System

Usually, a Decision Support System (DSS) is a system aimed at supporting decision-makers in taking appropriate and effective decisions based on evidences and best practices. Specifically, the VINTAGE DSS is intended to be an advanced expert system able to offer a clear understanding of the current situation *(what is going on in the field)* by integration of heterogeneous sources of data: sensors placed directly on the areas of interest, satellite imagery, state of the art models.

DSS is based on the output of well-established and consolidated models applied to viticulture, and assist the users in day to day management procedures, thanks to a user friendly web interface, assessing for instance the unique watering needs of each single parcel, controlling the growth phase of the grape, along with its vigour and maturity, optimizing at the same time the usage of fertilizers and parasiticides and limiting operators intervention on the soil and on the plant.

The DSS is not meant as a unique and separated result to be commercialized but as the main engine to run the final web services. Based on this assumption, it was agree to not define a specific exploitation strategy since it is strictly linked to the approach agreed for the commercialization of the results n° 3 and, therefore, for the provision of VINTAGE web services.

Moreover, in order to fill the engineering gap aimed to have available an actual service exploitable commercially, the following actions have been identified and will be carried out behind the end of the project:

- improve performance converting DSS in C/C++ software programming language;
- improve its “intelligence” by developing new rules;
- improve its capacity to work at pixel geographical scale and not at vineyard scale.

AG partners are co-owners of the result, whilst Bodegas has the right for an unlimited free use of DSS. GAIAG, as system administrator, will be in charge of the maintenance and the potential upgrades of the DSS.

3. VINTAGE Web Service

With VINTAGE web service, it is mean all modules necessary for the workflow able to enable the complex architectural process: database-module: it is responsible to provide a standard relational DBMS access to all GIS (and not-GIS) data. It stores, organizes and exposes data by a standard SQL interface; publish-module: it is responsible of offering to users GIS data as international standardized web services.

Web service interface is the highest interaction level and allows clients to perform complex queries in a web environment, for both vector and raster data sources. The system supports international standard services.

In order to have available an actual service exploitable commercially, the integration with other international web service standard for geospatial data management on the basis of developments will be assessed and performed during the following industrialization period.

Here below is reported a short example of business case applied to the Italian national scale:

N° of wineries > of 5 He: 119.338

N° of their He: 203.856

Estimated price of VINTAGE service for one hectar: 29 euro per month

Success rate: 2%

Annual revenue from selling of VINTAGE service to 2% of wineries => 4.076*29*12 = 1.419.492 €

AG partners are co-owners of the result, whilst Bodegas has the right for a free use of platform. GAIAG, as system administrator, or its subcontractors, will be in charge of the maintenance and the potential upgrades of the platform. It will be also the right to commercial exploit the platform in Italy for two years after the end of project as well as to assess further application domains.

Final report on the distribution of the European Union financial contribution

This report shall be submitted to the Commission within 30 days after receipt of the final payment of the European Union financial contribution.

Report on the distribution of the European Union financial contribution between beneficiaries

Name of beneficiary	Final amount of EU contribution per beneficiary in Euros
1.	
2.	
n	
Total	