DELIVERABLE 5.2-a

Testimony of Agronomy Days

MONTH 12 – Submitted on 21 December 2017

Detailed description of the activities performed in the first Agronomy Day. Analysis of the questionnaire passed to the attendees.

SYM
UPV

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First Agronomy Day on a glance

The First Agronomy Day of the VineScout project took place on 30 August, 2017, in Quinta do Ataíde (Portugal), a commercial vineyard owned by the company Symington Family States, which is a partner of the project (SYM). This event is officially programmed to be part of the annual steering weeks. The First Steering Week (SW-1) was initially planned for month 10, i. e. September 2017, but it actually took place earlier than scheduled for whether-induced reasons, as it occurred between 28 and 31 August, 2017. Our initial objective is to synchronize the steering weeks with the harvesting season at the testing site. The average temperatures in the summer of 2017 were unusually high. The climate data collected by SYM, with an automatic weather station in the field, gave a GDD (Growing Degree Days, which is a climate-based indicator for assessing crop development, and it is the sum of the daily temperatures above 10 ºC) of 2466 ºC·Days for 2017, respect to 2190 ºC·Days in 2016, which resulted in a two-weeks anticipation of the harvesting time at Quinta do Ataíde.

According to the agenda set for this first edition of agronomy days (Annex II), the activities began at 9.30 and continued until approximately 5 pm, with the survey to end-users as the final event. Overall, there were 28 attendees distributed as follows: eight people coming from academia, two attendees from governmental institutions, and 18 people from private companies. The following sections of this document provide a visual narrative of the activities carried out during the first Agronomy Day, analyze the results of the official surveys filled by the attendees, and propose a set of amendments to improve the following editions of this already successful event.

Analysis of the end-user questionnaire

Even though the number of attendees was 28, only eight managed to fill the complete questionnaire at the end of the day. This analysis of the results focuses on the features that are more valuable for the design and construction of the second prototype, which will be tested and validated during the Second Agronomy Day. The characterization of the sample group who filled the survey is based on two aspects: their **age** and the type of **professionals**. These are two sensitive features at the time of studying technology adoption. In terms of robot external design, we look at how users perceive its **physical endurance** and the easiness of **maintenance**. During the field demonstration, the robot was running in straight guidance, and we asked attendees to pay attention to the **stability of straight navigation**, the working **speed**, and the **safety** systems embedded in the robot. Data processing and handling was also explained in the Agronomy Day, but it will be more important for the next prototypes, and therefore it will not be analyzed in this first edition. We ended the survey with two crucial questions for launching a commercial robot: the perception of the user about the estimated **retail price** of 18,000 €, and what they foresee to become the **main barriers** to adapt this technology worldwide. In addition to answer the items included in the questionnaires, several attendees provided their recommendations in a free-text box. The following figures illustrate the results obtained in the questionnaires for these sections.

Population statistics

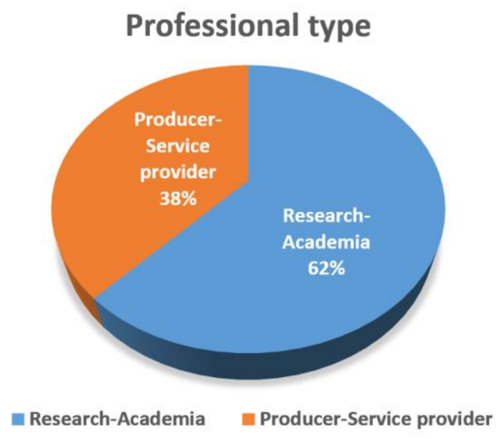


Figure 1. Professional type.

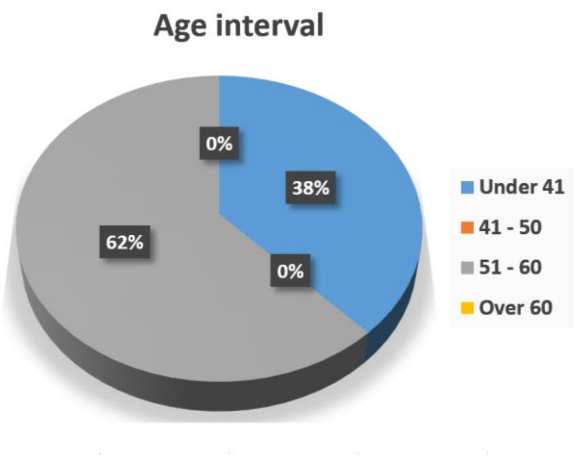


Figure 2. Age interval.

Robot external design

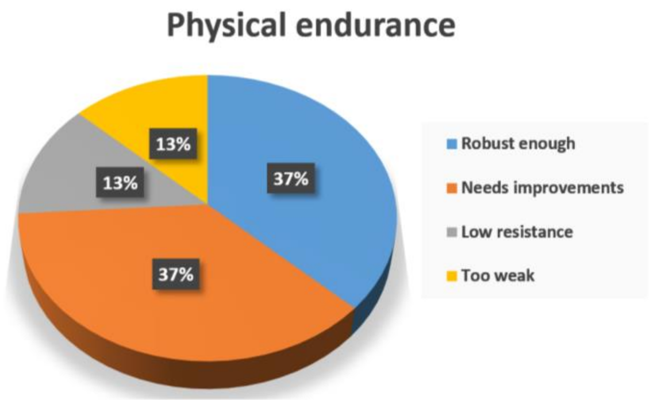


Figure 3. Physical endurance.

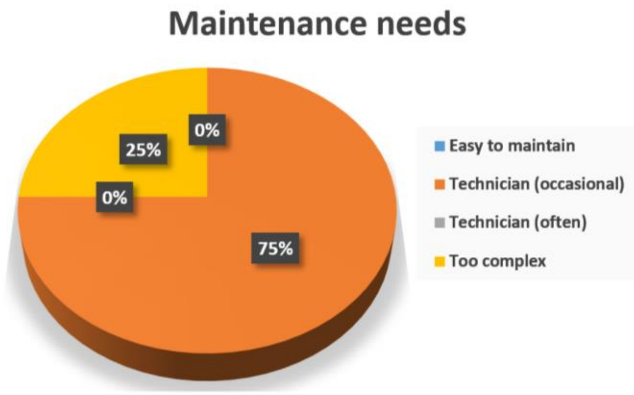


Figure 4. Maintenance needs.

Robot intelligence

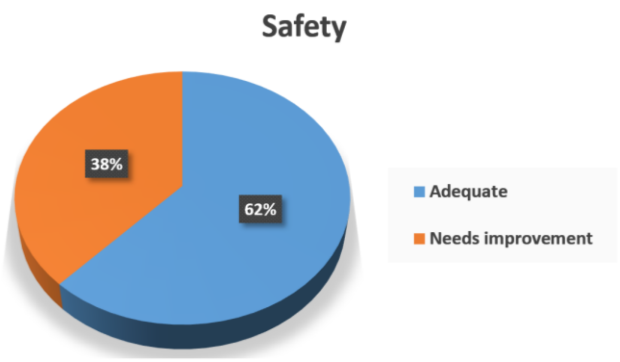


Figure 5. Safety features.

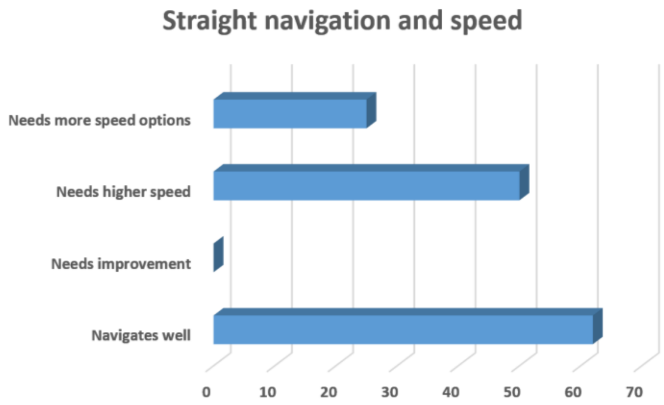


Figure 6. Straight navigation and monitoring speed (% votes).

Other aspects

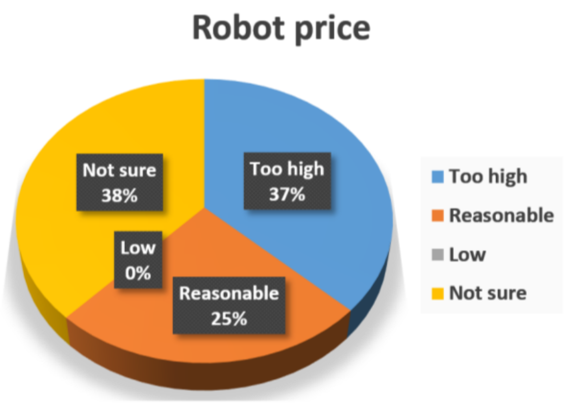


Figure 7. Retail price of robot.

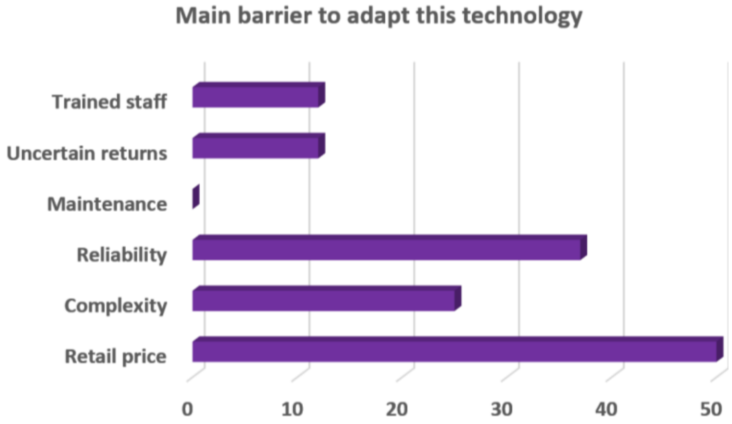


Figure 8. Main barriers to adapt this technology (% votes).

End-user recommendations

The following suggestions were written down by the attendees at the end of the questionnaire:

- Add a multispectral camera with single lens (recommended twice).
- Get 3D images with a stereoscopic camera.
- Compatibility with GIS systems.
- The screen monitor needs higher contrast.
- Improve end-of-row detection.
- Contact emergency stop in manual mode.

Conclusions

Before analyzing the answers given by the attendees who completed the survey, it is important to describe the characteristics of the group providing an opinion. According to figure 1, only one third of the group was formed by producers or personnel coming from companies providing data services to agriculture. The other **two thirds** were **researchers**. This trend should be inverted in upcoming events in order to get more feedback from the final user side. It was not easy to mobilize the wine-producing sector in the beginning of 2017 harvesting season (30 August), whereas researchers and academic staff had more flexibility at the end of the summer. As for the age of participants, the group was polarized; one third was under 41 years old while the rest belonged to the **interval 51-60** (figure 2). These figures make obvious that a much **greater group is needed** to cover the whole spectrum, and as a result, to find more significant evidences of the next steps for the robot's production.

A key objective for the First Agronomy Day was to extract information about a primal prototype of the robot with basic functionality from a group of stakeholders with little –or none– previous experience with agricultural robots. In particular, we looked at two complementary areas of the robot design: the **external structure** and the artificial **intelligence** embedded in the central processor. Figure 3 evidences that approximately one third of the participants believes that the early version was strong enough to endure the typical environmental conditions of vineyards, another third concluded that the current design needs some improvements, and the last third thought that endurance was not sufficient at all, and great improvements were needed. Overall, most of the participants thought that the robot needs to **improve its physical resistance** before it can be released. In terms of maintenance, 75 % of the people believed that a **technician** should be **occasionally providing assistance**, whereas only 25 % found the system too complex for average end-users no literate in digital technologies, especially with potential issues caused by the robot electronics and computing systems (figure 4). After running the robot in autonomous mode over several rows of approximately 100-m length, figure 5 proves that two thirds of the participants felt that the **safety** features of the robot are **adequate**, although the other third concluded that they **need improvements**. Yet the robot did not suffer any incident under automatic guidance along the rows. In the demonstration, only **straight guidance** between rows was evaluated. According to figure 6, 62 % of those polled said that autonomous navigation **was correct**, and nobody answered that it needed improvements. However, 50 % of the surveys stated that the robot needs moving faster, and 25 % found that more speed options will be necessary in the future for the practical use of robots. The prototype tested possesses a strong torque in the wheels to climb and roam over rough terrain, but its average speed is 1 km/h, which was considered **too slow** for the expectations of the attendees. Figure 6 illustrates the opinion of the participants about straight navigation and monitoring speed of the prototype used in the Agronomy Day.

Finally, we focus on two crucial aspects that affect the future **exploitation** and **commercialization** of the robot: its final selling cost and the main barriers that may block the generalized adoption of scouting robots for grape and wine production. Despite the fact that the targeted **retail price of the robot**, currently 18,000 €, was not explicitly mentioned in the questionnaire, the cost of the robot raised several questions and discussions along the field day, and therefore these discussions were the base for answering the price question of the survey. Figure 7 represents the results, which indicate that nobody thought that the price was low; on the contrary, 37 % of the people assured that the retail price was **too high** and another 38 % declared they were not sure about the price, which makes sense because most of the attendees were not familiar with field robots. Interestingly, 25 % of those polled affirmed that the price was reasonable. The discussion on the **price of the robot** resulted to be of **great importance**. As a matter of fact, among the main **barriers to put this technology in the market**, chosen by the participants as illustrated in figure 8, the **major obstacle** is actually the **selling price** of the robot, selected by 50 % of the surveyed. The **second barrier**, mentioned by 37 % of the polls, is **reliability**, which was *a priori* expected to be the highest. **Complexity** was also considered a barrier by 25 %, as well as **uncertainty returns** (12 %) and the **lack of a trained staff** in robotics and automation. Surprisingly, nobody thought that the need of a specialist to carry out maintenance tasks might become a barrier, probably because most of the attendees indicated (figure 4) that the needs of a technician would likely be occasional.

The specific recommendations made by the attendees that filled the questionnaire also resulted helpful for the planning of the second year, although not all of them were aligned with the main objectives of the project. The fact that two surveys mentioned the benefits of adding **multispectral perception** is significant, because we had already arrived to such conclusion, and consequently the second prototype VS-2 is expected to incorporate a multispectral camera. The collection of 3D images, on the contrary, is not currently a priority task for the end-user (SYM), focused on water status assessment. Nevertheless, it would not imply a big modification of the robot architecture because it already implements a stereoscopic camera for straight navigation. The compatibility of local-based flat east-north maps (generated by the robot mapping engine) with conventional GIS systems raised an intense discussion on the round table of the afternoon session. This issue is going to be considered in future versions of the mapping algorithm, probably for VS-3, given that it could improve the marketability of the robot. The observation made on the insufficient **contrast of the control screen** is important from a practical standpoint, as the robot is designed and made to work in the field, and most of the times in the summer when sun radiation is strong. Constructive comments like this that come from external observers are very helpful, because developers somehow get so used to work with the robot that do not realize of practical inconveniences like a weak contrast or the unfortunate location of a switch. One of the participants realized that the robot did not stop at the end of the row by itself. The turning routine at the headlands is under review, and was not activated in the tests. This will be one of the key features to evaluate in the next field event. The addition of a contact emergency stop in manual mode demands more thoughts, but one of the possibilities under consideration for VS-2 is the upgrade of the **joystick** with a more ergonomic grip that could additionally incorporate an emergency stop.

Feedback-induced actions for the second prototype VineScout-2

The objectives –both ideological and practical– of the Agronomy Days were satisfactory met in its first edition, as the robot was tested by a group of stakeholders who filled a survey at the end of the day, providing feedback on their experience in a real environment. This feedback was intended to power the iterating design of the robot in such a way that convergence between the solution proposed by the consortium and the needs claimed by the actual producers is continuously increasing until the deployment of a final model, properly industrialized and ready for production. The following actions, straightly derived from the experiences lived in the First Agronomy Day, will be taken into account for the design of the second prototype, which is expected to be ready for the Mid-project meeting, scheduled for May 2018 in Valencia.

1. The **external cover** of the robot and its design are going to improve in order to increase the physical resistance to potential impacts and weather influence (moisture, sun radiation, overheating), and also to increase the durability. The new body will be more **compact** and the computing components will be optimally ventilated. The new suspension design with four independent springs will include **shock absorbers** to palliate the effects of vertical accelerations caused by terrain irregularities. Intense testing to **evaluate fatigue** in the structure, body, steering, and electronics will be conducted between May and August 2018.
2. To diminish the need of regular assistance from maintenance specialists, which has been reported as an important concern by users (figure 4), an effort will be made to make **components easily exchangeable** by operators in the field. New batteries that are easily accessed and replaced, and a novel design of the electronic network are intended to expand the time between maintenance visits.
3. Although 62 % of the participants in the survey declared that the safety features were good enough, we did not challenge the robot in headland turnings or with rows of highly irregular shape, and therefore **safety** remains an important **source of work** for the coming months. The sonar network, in particular, is currently been redesigned with the goal of enhancing obstacle detection, and intense developments are expected in the spring 2018 to improve the routine for **headland turning**.
4. There was a consensus during the field tests on the needs for doubling the forward velocity of the robot. The VS-2 will be equipped with a different gearbox for the four-wheel motors in such a way that **more speed options** are available without affecting the torque needed to traverse rough terrain.
5. The majority of attendees believed that a retail price of 18,000 € is too high, and it may become the principal barrier preventing the adoption of robotic scouting in commercial vineyards. Deliverable D6.1-a will analyze the possibility to **reduce the selling price significantly**. One of the proposals under consideration will consist of launching **two versions** of the VineScout; a **basic robot** with simple functionality at a very competitive cost, and a **premier version** with more sophisticated set of functionalities.
6. A **new** touchscreen **monitor** manufactured by National Instruments with higher contrast and better protection options will be installed in VS-2 in January 2018. Other options for the joystick are being studied as well.
7. The monitoring of nitrogen content in vines through the vegetative index NDVI will be carried out with a **multispectral camera** with simultaneous perception in three spectral bands located in the green, red (edge) and infrared spectra. SUN and UDLR are negotiating with camera manufacturer JAI the assembly of a **customized** camera for measuring the NDVI. This camera will be ready for the field tests in the summer of 2018, and the Second Agronomy Day.

Visual narrative of the activities

9h30	Welcome address and purpose of Agronomy Days within the VineScout project Francisco Rovira-Más (Coordinator) / Symington Family Estates; Translation by SYM team
9h45	How the VineScout robot works: hardware and software Francisco Rovira-Más (UPV); Simultaneous translation by SYM team


10h00	Good practices and current limitations to assess vineyard status; what the robot can measure María Paz Diago (UDLR) and Fernando Alves (SYM)


10h30	Coffee break


10h45	Hands-on experience with the robot: measuring runs and data gathering. *All attendees*


12h45	Lunch and wine tasting social with invited end-users


14h00	Brief introduction of all attendees: consortium, Project Officer, Advisory Board members, and group of invited end-users who will explain their current activities and interests
14h30	Mapping techniques and interpretation of the robot data taken in the morning session Verónica Saiz-Rubio (UPV); Simultaneous translation by SYM team

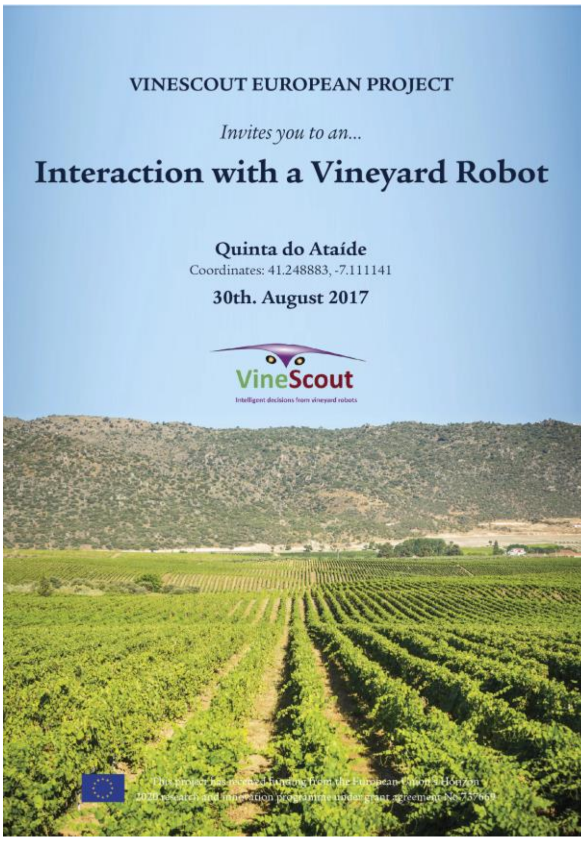

15h00	Agronomical decisions based on field data: evidence versus intuition María Paz Diago (UDLR); Simultaneous translation by SYM team
15h30	End-user-driven round table discussion: lessons learned and upcoming steps. Moderated by Pedro Leal da Costa (SYM)
16h30	Official questionnaire to end-users Administered by UPV & SYM teams

Improvements for the Second Agronomy Day

The First Agronomy Day was a **successful** event that fulfilled its purpose of **project visibility** and gathering of **sensitive information**. However, it can **significantly improve** by taking the following actions:

1. **Increase** the total number of **attendees**, from 28 to at least 40.
2. **Increase** the percentage of **producers and service providers** completing the questionnaire, such that we can invert the trend of the First Agronomy Day plotted in figure 1.
3. Collect at least **30 questionnaires** to allow for a much deeper analysis of user real needs.
4. Increase the presence of **attendees from other countries**.
5. In the first edition, there was no member of the **Advisory Board** due to the inconvenient dates for those related to wine production. In order to reinforce the key role of the Advisory Board, two measures are proposed:
    a. **Expand the board** by inviting more experts to join the AB.
    b. **Enrich the diversity** of the members composing the AB. The new board could include experts in robotics and automation, machinery manufacturers, service providers, or even growers.

Annex I: Invitation flyer



Who are we?

A European Union Horizon 2020 Research and Innovation program; Grant Agreement Nº737669 comprising of two Universities, two programing, software and robotics companies and a wine producer.

Universitat Politècnica de València - Spain
Universidad de la Rioja - Spain
Wall-YE Robots & Software - France
Sundance Multiprocessor Technologies Ltd - UK
Symington Family Estates - Portugal

Our Objective

To design a ready-to-market robot that autonomously and automatically monitors the vineyard. Plot key parameters and help growers monitor their grapes to achieve the best possible results.

Our Vision

To make the first vineyard robot available in the International market and to place Europe at the forefront of technology based viticulture.

Your Contribution

Participate in our field demonstration, let us know your requirements and give us your feed-back and suggestions and take part in the future of viticulture.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 737669

Annex II: Agenda

Agronomy Day Agenda

Quinta do Ataíde, Wednesday 30th August

9h30	Welcome address and purpose of Agronomy Days within the VineScout project Francisco Rovira-Más (Coordinator) / Symington Family Estates; Translation by SYM team
9h45	How the VineScout robot works: hardware and software Francisco Rovira-Más (UPV); Simultaneous translation by SYM team
10h00	Good practices and current limitations to assess vineyard status; what the robot can measure María Paz Diago (UDLR) and Fernando Alves (SYM)
10h30	Coffee break
10h45	Hands-on experience with the robot: measuring runs and data gathering. *All attendees*
12h30	Transportation of attendees from field to picnic area in front of presentation room
12h45	Lunch and wine tasting social with invited end-users
14h00	Brief introduction of all attendees: consortium, Project Officer, Advisory Board members, and group of invited end-users who will explain their current activities and interests
14h30	Mapping techniques and interpretation of the robot data taken in the morning session Verónica Saiz-Rubio (UPV); Simultaneous translation by SYM team
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15h30	End-user-driven round table discussion: lessons learned and upcoming steps. Moderated by Pedro Leal da Costa (SYM)
16h30	Official questionnaire to end-users Administered by UPV & SYM teams

Registration

Fernando Alves (SYM): + 351 91 8242929 | fernando.alves@symington.com
Joana Valente (SYM): + 351 91 4064569 | estagio.viticultura@symington.com

Clothing

We recommend comfortable outdoor clothes and shoes (bring a hat)

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