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Executive Summary

This document aims to provide an overview of the foreground knowledge from the PANTHEON project and its possible ways of exploitation.

The following aspects have been analysed:

- Dissemination and communication during the project
- Protection of the intellectual property during the project
- Exploitable foreground and plans for exploitation.

Table of Content

Abbreviations and Acronyms

IP	Intellectual property
CCTA	Conference on Control Technology and Applications
MED	Mediterranean Conference on Control and Automation
PER	Exceptional Research Project
FNRS	Fonds national de recherche scientifique
PDR	Projet de Recherche

1 Goal of this deliverable

This deliverable describes:

1. The activities of dissemination, communication, and exploitation that the Consortium of PANTHEON has carried out during the project
2. The plan for the future dissemination, communication and exploitation of the foreground knowledge.

In particular, this document collects information about the different results generated during the project and provides a series of guidelines for the future exploitation of this knowledge, as well as guidelines on the management of the information property (IP).

2 Dissemination and Communications during the project

2.1 Organization of the disseminations and communication activities

An important amount of dissemination and communication actions have been carried out throughout the duration of the project PANTHEON.

From the beginning, the intention was to focus on a number of different dissemination targets which are relevant for this project. The following table provides a synthetic summary of the different targets, of the motivations of why they were targeted, as well as the means that at the beginning of the project were foreseen to reach them.

Target	Why	How
Scientific Communities	*To disseminate the knowledge developed and contribute to the advancement of research. To create new collaborations.*	*Scientific Publications* *Participation to Conferences* *Engagement in Committees* *Organization of Workshops*
Hazelnut farmers and farming companies	*To generate interest, to disseminate results directly applicable, to pave the way to future exploitation.*	*Contacts with Hazelnut farmers' associations and through the FERRERO internal and external network. Communications, newsletter, online forums, articles in associations' magazines, workshops and seminars, courses by UNITUS.*
Agricultural world "at large"	*To generate interest and raise awareness, to trigger possible new projects on other farming context with similar problems*	*Contacts with farmers' associations, communications, articles in associations' magazines, seminars.*
Agricultural high schools and university	*To generate interest and impact the new generation of agricultural operator.*	*Seminars with high visual impact, Q&A sessions with the students*
Technological Companies	*To create interest, to find possible technological partners/providers for the follow-up activities. To commercialize results obtained in the project.*	*Use the meetings of innovation clusters to disseminate results and to have face-to-face discussions. Network of Contact Points of the partner SIGMA.*
Funding Agencies	*To explore the possibility to find funds for follow-ups project, or for the possible opening of spin-off*	*face-2-face discussions* *Institutional Meetings and Reviews of other projects*
All the above + others (including general public)	*To disseminate the new knowledge to all interested actors, to create in general interest in the project, which can be useful for possible follow-ups*	*Website* *Social Media* *High Impact Videos on Youtube* *EU Mechanisms*

Table 1: Dissemination Interventions by Targets

Concerning communication, the following actions were foreseen concerning various types of media:

- **Mass Media -** The project partners were encouraged to engage in communication with local, regional and national mass media with the goal of reaching the widest possible public. At the beginning of the project, the members contacted press agencies, newspaper, radios and televisions to communicate the project, its aim and its vision. Major advancements and experimental tests were communicated too and were covered by various media.
- **Popular Science and Technology** - Popular science and technology media and possible organizations interested in a more sustainable concept of agriculture (e.g. environmentalist groups) received communications from the consortium about the goal of the project. Journals, Magazines and TV programs of scientific vulgarization were targeted too.
- **Participation to Fairs / Events / Open days -** The researchers of the project were encouraged to participate to Fairs and Public Events to communicate to the public both the aim and the current status of the project.
- **Ferrero Communication -** The partner FERRERO has a very developed communication network whose effectiveness is demonstrated by many successful campaigns. The objectives and the most relevant results of the project have been used for some of their communication activities.

To measure the effectiveness of the various dissemination and communication actions, a number of Key Performance Indicators for the dissemination and communication activities were foreseen in the project and are reported hereafter.

Venue	Indicator	Poor	Good	Excellent
Website	#of visits	<1000	1000-5000	>5000
Social Media	#of followers	<50	50-100	>100
Scientific Publications	#of peer reviewed papers accepted	<15	15-25	>25
Scientific Workshops	#of scientific workshops organized	<1	1-2	>3
Agricultural Schools	#of seminars held	<3	3-6	>6
Hazelnut Farmer's associations	# of press release + # of article in bulletin/magazines + #entry in associations mailing lists + #of intervention to public meetings	<5	5-10	>10
General Farmer's Association	# of press releases + # of articles in bulletins/magazine + #entries in associations mailing lists + #of interventions in public meetings	<2	2-4	>4
Mass Media	#of appearance on mass media of regional or national relevance	<2	2-5	>5
Popular Science	#of appearance on popular science media	<1	1-3	>3

Table 2: Key Measurement Indicators for Dissemination and Communication Activities

2.1.1 Material for dissemination

During the very first months of the project the material to be used for dissemination was created. The goal was to make the dissemination easier for the members of the Consortium and also to provide clear guidelines to get a coherent and recognizable communication style across the different units the project.

Initially we created a logo with a clear meaning related to PANTHEON. This logo was part of a "dissemination package", containing models and templates for all the written dissemination and communication forms of

the project. The dissemination package also contained clear indications on how to acknowledge the European Commission, using a standard sentence that could be used throughout the entire duration of the project.
A template for the slides of the project was created, as well a set of slides for the general dissemination of the project, to be used every time we presented the project to a large audience. Several posters presenting the concept of the project were prepared, too.

For communication with the general public, we wrote and designed a storyboard and commissioned the development of a comic strip for the project, organized in a leaflet that has been widely during the whole project.

2.2 Activities carried out during the project

The project PANTHEON has kept a good pace in terms of communication and dissemination activities during the whole duration of the project. These initiatives, as previously detailed, have been divided into several topics and targets. Additionally, they have been carried out at different periods of time based on the results available and the project stage.

Press releases were carried out at the beginning of the project when each member of the Consortium released several statements about the project PANTHEON and the nature of its activities.

The appearance of PANTHEON in the **mass media** has been consistent during the entire duration of the project. Notably, PANTHEON was featured by national newspapers like *Il Messaggero* or *Corriere della Sera.* At the international level, the project was featured in 2019 on Euronews and at the beginning of 2021 on VTVW (Vietnam national TV). Also, PANTHEON project was featured twice in **Popular Science and Technology Media**, being part of an issue in 2020 of the Italian magazine Platinum business leaders.

The members of the consortium have been very active in their participation to **fair and events**. Namely, we have participated to the MAKER FAIR ROME or the European Robotic Forum in two occasions, to the Brussels Drones' Days, and have given a plenary speech at the Drone World Congress 2019. Since March 2020, due to the COVID-19 outbreak, the number of fairs and events has been almost non-existing, creating a need of promoting the PANTHEON project in other ways.

The project **website** and **social media** have been two essential tools for the dissemination of the results of the project and the promotion of the different activities organized by the members of the consortium. They have been used to contact people around the world, reaching critical levels of importance during the period 2020-2021 when physical meetings were not possible. This situation also urged the creation of a high amount of multimedia material to share in these platforms. In this context, several videos have been displayed on the website of the project and on the Facebook and Linkedin accounts. Most of these videos have been created by PANTHEON members and have been very helpful to show the achievements attained by the different units.

Another important aspect of the project has been the **communication toward Hazelnuts farmers** and **toward General Farmers Networks and Associations.** This communication has been carried out by means of articles published in venues like the *Information Bulleting of the Research Network on Nuts* but also by public presentations like the one given in 2021 at the *Convegno Confagricoltura Umbria.*

As most of the results obtained in this project were of scientific nature, the **dissemination toward National Organizations for Industrial and Research Development** has been fundamental in terms of future exploitation of the different scientific achievements. In this sense, the members of the consortium have

presented the project to various institutions in Belgium and Italy. Also, some of the developed concepts have been introduced to **companies** in the sectors of technology and agriculture.

Regarding scientific dissemination, several **scientific Workshops** were organized at prestigious international conferences like the CCTA 2021 (Conference on Control Technology and Applications) and MED 2021 (Mediterranean Conference on Control and Automation).The **dissemination toward students** was also considered a crucial aspect of the dissemination and communication strategy and it was carried at different levels targeting primary and secondary school students, agriculture related faculties, and engineering faculties. Lectures to students of the Master course in Precision Agriculture organized by Università della Tuscia or to students belonging to the European exchange program Erasmus+ were also organized.

All the details on these activities are reported in the Annex (Section 7). Hereafter we report a synthetic description of the communication activities with respect to the above detailed KPIs.

Venue	Indicator	Poor	Good	Excellent	PANTHEON
Website	#of visits	<1000	1000-5000	>5000	Approx. 5000 visits
Social Media	#of followers	<50	50-100	>100	Most popular post: 1700 people reached, 500+ engagements
Scientific Publications	#of peer reviewed papers accepted	<15	15-25	>25	14 peer reviewed conference papers 10 journal papers 2 book chapters 2 peer-reviewed ext. abstracts 6 extended abstracts
Scientific Workshops	#of scientific workshops organized	<1	1-2	>3	3 scientific invited sessions
Agricultural Schools	#of seminars held	<3	3-6	>6	2 in agricultural schools 3 lectures in Engineering Faculties 1 seminar in primary school
Hazelnut Farmer's associations	# of press release + # of article in bulletin/magazines + #entry in associations mailing lists + #of intervention to public meetings	<5	5-10	>10	1 entry in a mailing list (Ferrero) 1 presentation 3 articles in national magazine
General Farmer's Association	# of press releases + # of articles in bulletins/magazine + #entries in associations mailing lists + #of interventions in public meetings	<2	2-4	>4	3 articles in national bulletin/magazine
Mass Media	#of appearance on mass media of	<2	2-5	>5	3 national newspaper articles

	regional or national relevance				2 local radios interviews 2 online regional newspapers 2 appearance in international mass media
Popular Science	#of appearance on popular science media	<1	1-3	>3	2 appearances on popular science media

Table 3: Key Measurement Indicators for Dissemination and Communication Activities

It must be noted that some of the dissemination and communication activities planned by PANTHEON had to be cancelled or modified due to the sanitary crisis that affected the world during the last two years of project. That fact unbalanced the overall dissemination activities distribution, forcing the creation of more multimedia content and restricting some public presentations to venues like schools or farmers associations.

3 Exploitation activities during the project

The ongoing exploitation of the knowledge generated in the project PANTHEON has been carried out along the three following lines:

- Scientific Exploitation
- Economic Exploitation
- Societal Exploitation

In the following we detail the exploitation of the generated knowledge along the cited lines.

3.1 Scientific Exploitation

The knowledge generated in this project has been mainly of scientific nature. This knowledge has been presented at different venues with a total of more than 30 scientific publications. These results have allowed the rise of several spinoff projects as well as new collaboration and research lines following some of the most promising concepts and the development of future and more specific research projects in the area of Precision Agriculture.

In the following we detail the new research projects that were based on PANTHEON findings.

3.1.1 Smart Testing and Selective Quarantine (Epidemics)

The work on disease monitoring within the PANTHEON project provided interesting results that could be extended to other case studies as the spreading of infectious diseases in human communities. The knowledge generated in PANTHEON served as the methodological basis for a successful submission to an Exceptional Research Project (PER) funded by the *Fonds national de recherche scientific* (FNRS) in Belgium about Smart testing and Selective quarantine in epidemics.

3.1.2 Population dynamics of insect pests

During the execution of PANTHEON, the discussion between the entomologists of UNITUS and the control engineers of ULB sparked a series of new ideas concerning the modelling and management of insect pests. The modelling of the population dynamics of insect pests and the insect's life cycle resulted in a scientific publication in the journal "Ecological Modelling" and several other articles submitted or in progress. Given the very good reception of this contribution by the scientific community, this activity sparked a number of joint project research submissions, and most notably an Individual Fellowship Marie-Curie that will be submitted in October 2021, and an FNRS Projet de Recherche (PDR) in collaboration with the Gembloux Agro-Bio Tech Centre of the University of Liege.

3.1.3 Modelling of water intake by hazelnut trees

The results obtained from the task of Water Stress Management (Task 4.6) showed that most of the indicators commonly used for water stress Precision Agriculture, such as soil probes or weather station data, were not suitable for a precise water management of hazelnut orchards. The need for finding alternative way of measuring water intake led to a partnership with the University of Padova and a future collaboration focused on the modelling of water intake by hazelnut trees focusing on alternatives methods like the measurements of tree SAP flow sensors.

3.1.4 H2020 CANOPIES

The experience of the PANTHEON project regarding the use of robotics in agriculture helped University of Roma Tre to envision and to start a new H2020 project in January 2021 titled "A Collaborative Paradigm for Human Workers and Multi-Robot Teams in Precision Agriculture Systems" CANOPIES. The EU-funded CANOPIES project explores a novel paradigm of human-robot collaboration in the field, facing the concrete test case of the harvesting and pruning operations in table-grape vineyards. The project will demonstrate how a team of heterogeneous robots, some with robotics arms, others with carrying capabilities, will operate alongside with farm workers, opening new perspectives on farm and crop management.

3.1.5 PARADISE project

During the PANTHEON project, SIGMA unit worked on the Architecture and integration of the system, the Data management, and the user application. The knowledge acquired in PANTHEON allowed SIGMA to start collaborating in a new research project, the PARADISE project. "PARADISE Project" is an environmental sustainability project promoted by the Lazio region in the field of Smart Farming for the cultivation of peaches and apricots.

Namely, the architectural approach defined in PANTHEON has been almost completely re-applied to the PARADISE project. The data structure defined in PANTHEON was used as a reference in the PARADISE project, especially in defining the field elements and agronomic activities. For instance, the Node-Red application will be reused to connect the data flows also in the Paradise system, modifying the flows appropriately.

A No-SQL database also has been reused for the management of the acquired data and the JSON format, both technologies work very well in the Smart Farming and IoT scenarios in general.

Additionally, many solutions used in the PANTHEON user interface have been taken as a reference to define the architecture, layout and graphic components to be used in the PARADISE project. The modular and generic approach used in PANTHEON has allowed the reuse of the knowledge acquired in a new project, which, in the same area of smart farming, involves the management of a different crop (peaches and apricots) and different agronomic activities to manage.

3.1.6 AGRORAMA project

The work in PANTHEON project demonstrated the necessity of improving the current monitoring approach in agriculture when performed by robotic units. Inspired by this need, Uniroma3 joined the research project AGR-o-RAMA. AGR-o-RAMA project is a regional project founded by the Lazio region which focuses on active monitoring for agricultural robots. This project aims at the study of autonomous intelligent drones capable of actively monitoring a field in order to identify and map features of interests (e.g., weed or pests) that could be distributed heterogeneously within the field.

3.2 Economic Exploitation

Some of the results obtained during the four years of project have been identified as marketable technology in follow-up activities by the industrial partner SIGMA.

The experience gained during the PANTHEON project had an economic impact on SIGMA since this unit, as a System Integrator, intends to include SMART FARMING among its core business activities, with a portfolio of product services presenting an offer that can be customized according to the customer's requests in accordance with each market. In this sense, Sigma is working not only at the national level, but internationally, specifically in Latin America. In fact, Sigma has already carried out a market analysis in Ecuador, analysing the main crops and the target market to which the Smart farming offer will be addressed. Also, SIGMA intends to start and expand the same business idea in other countries such as Brazil, Mexico, and countries of the South Asia.

3.3 Societal Exploitation

From the society viewpoint exploitation, project PANTHEON has allowed the members of the consortium to promote and communicate important ideas about precision agriculture and the use of new technologies to create a greener future. Namely, these contributions can be summarized as follows:

3.3.1 Use of drones in Agriculture

Professor Emanuele Garone (ULB) is currently part of the Belgian Drone Council of the Belgian ministry of transport. The experience of PANTHEON project, namely the work on the drone data collection and path planning, has been used to showcase the unnecessary complications linked to past and current red tape concerning flights for agriculture in Europe.

3.3.2 Sensibilization about technology in Agriculture

The different achievements during the project PANTHEON have contributed to the sensibilization of the public opinion about “Precision Farming”. The project results have allowed the promotion of the idea that farmers can use new technologies to improve the management of large-scale orchards and how these technological advances can help to make farming a greener activity.

3.3.3 Change of paradigm

The ambition of the consortium was to introduce a new paradigm in the management of large-scale hazelnut orchards. That is, evolving from the current uniform management at level of several hectares to the care at level of single plant. This change would result in an optimization of the use of resources (mainly water and inputs) while improving the health and productivity of the plants.

The project has proven the feasibility of monitoring the health status, growth rate and water needs at the single plant level. Besides, the viability of autonomously executing some orchards tasks (such as the sucker control) at the level of single plant has been validated. However, there is still a long way to fully achieve the change of paradigm (the management at single plant level) and make it commercially doable and financially attractive.

4 Protection Strategy during the project

From the beginning of the project, all partners received assurance that their contributions to the project based on their pre-existing know-how would be identified and recognized as such by other participants. Pre-existing know-how included knowledge developed before the beginning of the project, regardless of its being patented or secret, as well as results obtained outside the project after its start.

Knowledge exploitation was administered pursuant to the general provisions and the specific rules defined in the project's Consortium Agreement that followed the highest EC standards. The exploitation of knowledge involved all activities related to the protection of the intellectual property and the plans for its use. In view of the partners' specific legitimate interests, intellectual property rights (including patent searches, filing of patent or other IPR applications, etc.) were protected and safeguarded to ensure the smooth and efficient use of results.

This approach to knowledge and the IPR management was regulated in detail in the Consortium Agreement and was agreed upon by all partners before the project started. Some of the aspects covered included:

- **Confidentiality**: Each partner would treat information and data from other partners as confidential and would not disclose it to third parties without explicit authorization unless the information was demonstrably already public.
- **Ownership of Knowledge**: Knowledge was owned by the partners whose work had originated the knowledge, or on whose behalf such work was conducted. Partners wishing to assign knowledge to a third party, would inform other partners and the European Commission accordingly, and request their consent.
- **Patents**: Partners who owned patentable knowledge may (and were encouraged to) at their own expense apply for a patent or a similar form of protection and should supply the details of such an application to the other partners and to the Project Management Committee.
- **Access Rights**: Partners would grant each other royalty-free access to any knowledge generated within the project, to the extent needed for the project to be successfully carried on. Access rights to pre-existing knowledge needed for use outside of the project should be granted by owners to other partners at preferential conditions and only to the extent needed to enable the use of the project results.
- **Open Access Publishing**: All scientific outcomes would be provided in open access mode. In particular, the 'green' open access model would be used. Every scientific outcome generated in the project would be self-archived in three locations: on the project website, on arXiv, and on Researchgate to ensure maximal visibility. The researchers were instructed to publish only in journal and conferences ensuring self-archiving (green publishers). Exceptions to this policy were authorized by the Project Management Committee. The authorization to publish on journal/conference not ensuring self-archiving would be granted only if motivated by reasons of opportunity.
- **Software**: The consortium committed to make all the algorithms developed in the consortium of public domain and to not hide any information that can contribute to the advancement of science. Whenever relevant, high-level implementations (e.g. Matlab implementation) of the algorithms of scientific relevance will be make public through the project website. The software and libraries developed to make the SCADA system work (drivers, interface, etc.) would be released as Open Source software under GNU 3.0 license.
- **Data Set**: Whenever possible, all relevant nonconfidential data collected (e.g. measurements collected to calibrate the sensing algorithms) would be stored in a database that will be made accessible to the public to encourage further research on the subject.

During the project, some of these aspects were rediscussed in order to adapt to constraints and data generated. Particularly:

- **Open Access publishing:** Several articles were published in journals that allowed accepted versions of the articles but not final ones to be used on the PANTHEON website or alternative repositories (e.g. Researchgate). This issue was tackled by storing previous versions of the article with no copyright conflicts on the website and Researchgate, so to maximize the visibility while complying with the journal policies.
- **Software:** According to the philosophy "*as open as possible, as closed as necessary*", the consortium rediscussed the availability of the software used in PANTHEON. Given the possibility of economical exploitation of the software generated (mainly by SIGMA unit) or its use in other activities, the consortium agreed to keep the software confidential and only available to the other members of the Consortium during the project. An embargo of two years after the end of the project was decided to identify clearly which components to keep private, and which to be released. After the evaluation of this possible economical outcome, the non-exploitable software will be released for public use.
- **Data set:** The data generated in PANTHEON was decided to be embargoed during the duration of the project and the two following years. The idea behind this action was to allow the members of the Consortium to have priority over the use of the data during their research and the publication processes. Once this period will be completed, all data generated will be made publicly available to promote the research on the topic. To publicize the availability of the dataset a paper co-authored by all the parties involved in the data collection will be submitted to the relevant venues.

5 Exploitable foreground and plans for exploitation

5.1 Foreseen Dissemination and Communication after the project

This subsection summarizes the foreseen dissemination and communication activities planned by every unit after the end of the project PANTHEON.

5.1.1 ULB

The ULB unit will keep disseminating the results obtained in the project PANTHEON during the following years through academic courses and public appearances of the group. The unit considers that the knowledge generated in PANTHEON is a perfect example of control theory adapted to real life problems, more precisely, Precision Agriculture.

The work of the ULB unit in PANTHEON was based on the combination of several control subjects put into practice: drone path planning, optimal monitoring, and estimation techniques. This work will be shown as a study case of the activities of the SAAS group on how these subjects can be combined and their relevance in the field of agriculture.

5.1.2 UNIROMA3

UNIROMA3 is currently involved in other 3 projects (2 regional and 1 European) concerning precision agriculture. Indeed, the experience gained during these four years of PANTHEON has represented a great cultural background that worked as a solid starting point for the drafting first and the ongoing development of these other projects. The PANTHEON experience will be always remarked also during the dissemination activities of these other projects as our first and prototypal project on this research area.

The research activities at UNIROMA3 within the PANTHEON project have been along the line of control, robotics, and artificial intelligence. Indeed, these are core search areas for the people of the NEWLINE research group at UNIROMA3 involved in the project, and the methodological and experimental foundations built over these four years represent a cultural heritage upon which it will be possible to further develop novel research directions.

5.1.3 TRIER

TRIER unit will continue to develop and tune the fruit detection algorithms. Two different approaches will be studied as part of two independent master theses. It is then intended to publish these results in scientific journals related to the field. TRIER is furthermore trying to improve the index-based water stress and plant disease models, also with the intention to publish any significant progress.

5.1.4 FERRERO

The Ferrero unit is already communicating the PANTHEON project as an example of innovation in precision agriculture. The project has also allowed the unit to strengthen their network of academic researchers, opening up the possibility for future collaborations. After the success of the current project, the unit will seek further engagements with EU research programmes as an industrial partner.

The Ferrero unit will continue the research on precision agriculture with the objective of optimizing the management of hazelnut orchards and minimizing the environmental impact. As the PANTHEON project marks a milestone in hazelnut precision farming, the mid-term objective of the unit will be to turn some of the solutions tested during the project into scalable and commercial operative solutions, such as further developing the sucker management system.

5.1.5 UNITUS

UNITUS will focus mainly on the dissemination of the agronomic results obtained in the project and target academic venues to present their achievements in PANTHEON. In particular, regarding short-term dissemination activities, the local unit UNITUS is disseminating these "agronomic" results through the two following events:

I. Submitting manuscripts to the Special Issue "Recent Advances in Hazelnut spp." Edited by the Journal "Frontiers in Plant Science" (https://www.frontiersin.org/research-topics/13522/recent-advances-in-hazelnut-corylus), where the Principal Investigator of UNITUS is serving as Guest-Editor in Chief of the Special Issue.
II. Dissemination of the Project results during the next International Congress of Hazelnut edited by the International Society of Horticultural Science (https://hazelnut2022.org/), that will be held in Oregon State University of Corvallis (Oregon –USA) from 5th to 9th September 2022 (postponed one year for Covid restrictions). In this case the Principal Investigator of UNITUS is serving as member of the Scientific Committee of the International Congress.

Regarding crop protection aspects, all the acquisitions and in particular the monitoring techniques developed in PANTHEON will be used as case studies and applications that will be presented in academic courses. A document with the results obtained in the last season of experimentation is in preparation.

5.1.6 SIGMA

SIGMA has already started communication and dissemination activities of the experience gained in the Pantheon project, presenting it as a case study and by highlighting its features as important project at European level - both for the partners involved and for the results achieved.

The Pantheon experience is included (and will be showcased for several years) in brochures made by SIGMA and aimed at promoting Smart Farming, as well as presented in both private (commercial B2B meetings) and public events, such as webinars and trade fairs (Italian and international ones).

5.2 Foreseen Future Exploitation

In the following we detail the plans for the foreseen future exploitation of the knowledge generated by the project PANTHEON. The different activities are divided by unit and task.

5.2.1 ULB

Task 4.4 - Aerial Robot Planning for Monitoring – The methodologies developed in PANTHEON for the monitoring of water stress provided a new approach for the monitoring of large-scale orchards. The presented results were based on the use of the information available to adapt the flight of the drone to the areas that were more required in terms of information and not to base the path planning uniquely on geometrical aspects.

The presented methodologies are general enough that can be adapted to other natural phenomena and to the case of other kind of mobile sensors. Future lines of research include industrial scenarios where the use of UAVs for the monitoring of power lines can be improved by the use of an information-based approach adapted to large scale systems (some industrial project submission on the subject is ongoing).

Task 5.6 – Fruit development and production monitoring – The task of fruit monitoring showed that is possible to estimate the production of the whole orchard based on single measurements of some plants. The work carried out during PANTHEON allowed to design some protocols to improve the monitoring of the production. Future works will focus on further extending these initial results. Firstly, they will be validated by using more years of data and other plantations. Secondly, new lines of research may try to apply the presented protocols to other cultivars and observe the efficiency and similarities of behaviour in the production of other fruits.

5.2.2 TRIER

Task 4.2 – Terrestrial Remote Sensing Pipeline and Task 4.3 – Tree Geometry Reconstruction - In the PANTHEON project, algorithms for an automated processing of terrestrial laser scans and camera images were developed (D4.1). In particular, the algorithms were developed for the automated alignment of terrestrial laser scans and the extraction of the hazelnut trees. The extracted trees are the basis for tree geometry reconstruction (D4.2). Fundamental algorithms, e.g., for point cloud alignment, were integrated into the Python package *Pyoints* (Lamprecht 2019). In the future, the algorithms for the processing of the laser scans are planned to be exploited by Trier University to analyze forest inventory plots automated fusing of multiple terrestrial laser scans.

Algorithms for tree geometry reconstruction of multi-stemmed trees were developed (D4.2). These algorithms have been further improved by complementing the optimization procedure using methods of machine-learning. In the context of the PANTHEON project the algorithms have shown to be suited for the reconstruction of hazelnut trees and were the basis for automated pruning (D5.4). In the future, the algorithms might be used by Trier University for the reconstruction of multi- and single-stemmed trees in semi-natural forests of the mid latitudes and could be implemented in a software package to be released.

Task 4.5 – Aerial Image Processing Pipeline- The UAV data processing workflow was developed to derive the index raster data (D4.4 + D4.5). During the development, many parameters and subroutines of the orthomosaic processing had to be adjusted. Though it was not possible to fix the entirety of the technical issues, a lot of detailed knowledge was gained on how to optimize the geometric and radiometric quality of the remote sensing products. This knowledge is going to be exploited internally and will be very helpful in future projects. The algorithms and python scripts will also be reused internally, but the reusability will be limited by the deprecation of parts of the metashape package as well as hardware specifics of the sensors

used in the project. The analysis of the derived indices showed some significant correlation with the necrotic areas for some but not all measured dates. As such, future work will focus on improving the predictive power of these indices.

Task 4.8 – Fruit Detection – This task presents two different approaches to predict the presence of visible nuts in the data. Firstly, the use of an image-based convolutional neural network approach to detect fruits, and secondly, the detection of nuts on the Lidar derived and spectrally enriched point clouds. These findings will eventually be published, and also to use the know-how in object detection and point cloud segmentation internally in future projects.

5.2.3 FERRERO

Task 2.2 – Dimensioning of the real-world (1:1 scale) hazelnut orchard – The FERRERO unit developed a detailed description of the dimensioning of a hazelnut orchard to conduct a real-word (1:1) field trial (Deliverables D2.1 and D2.3). The procedure does not only outline an analysis of the orchard management requirements, i.e. which orchard operations are most time-consuming in managing a real hazelnut orchard, but also describes the functional specifications of the field trial as well as identifies appropriate means to verify the outcomes of the field trial.

The most time-consuming and labour-intensive operations in a commercial hazelnut orchard comprise pruning, sucker detection and treatment, pest and disease detection, harvest estimation and irrigation. These outlined operations acted as the backbone of the SCADA concept to be developed by the consortium.

The described procedure, with some further improvements and fine tuning, can be adopted in possible future field trials conducted by Ferrero agronomists or, more broadly speaking, by the hazelnut farming community.

Task 4.6 – Water Stress Measurement - Water stress measurement based on multispectral and thermal drone imagery has been extensively researched in a number of fruit species (vines, almonds, apples, etc.). However, no field trial was set up yet in a hazelnut orchard. During the project we managed to set up the first long-term trial in hazelnuts, where data from ground-based sensors (soil moisture sensors, sap flow sensors and dendrometers) were compared to vegetation indices (NDVI, NDWI and thermal) calculated from drone images. From the scientific point of view, this was a milestone in the irrigation management in hazelnut orchards. The data obtained during the project haven't been fully exploited yet but will enable FERRERO to set up new trials that will eventually allow us to monitor the water status in a commercial scale with images capture by drones or satellites.

5.2.4 UNIROMA3

Task 3.2 - Localization and Navigation of the Ground Robot - An autonomous navigation architecture for Ackermann steering vehicles has been purposely designed for navigating large-scale hazelnut orchards. To achieve this objective, the proposed navigation architecture relies on two major components: i) a local planner and ii) a tailored pose regulation control law. In particular, the local planner generates in real-time optimal trajectories by considering both the Ackermann kinematics and the obstacles (e.g., trees, rocks, etc.) that might lie, or dynamically appear, along the route. The outcome of the local planner, i.e., a trajectory described by a sequence of desired poses, is then fed into a non-smooth control law that ensures the convergence toward each of these configurations. This control law, which is inspired by control techniques originally applied to the unicycle kinematics, has been purposely designed ex novo to solve the pose regulation problem for vehicles with Ackermann kinematics.

The navigation stack developed within this project enables future works involving autonomous navigation within large-scale fruit cultivations for vehicles characterized by an Ackermann kinematics, which represents a very common kinematical model for agricultural vehicles and machines.

Task 5.1 – Sucker's management protocol - An automatic suckers' treatment protocol has been developed within the project to treat individually the suckers of each tree of the orchard. The automatic system consists of two phases: first, a robotic platform navigates the orchard and scans the target trees using an RGB-D camera; then, the video data is fed to a neural network which recognize the presence of the suckers and enables the 3D semantic reconstruction of the suckers. From the 3D reconstruction information about length, size, volume, and more properly the surface area of the suckers is retrieved and an estimate of the amount of herbicide that each tree requires, is computed. At this point, the robotic platform can autonomously be sent to the target trees to hand out the computed herbicide amount using an automatic sprayer equipped of proper nozzle and mounted on the robotic platform.

This sucker management system allows to optimize the amount of herbicide to be sprayed, thus allowing for a fundamental transition from chemical inputs to more sustainable solutions. Indeed, this would pave the way for another critical step forward towards a more environmentally friendly approach for agricultural management. In addition, it should be noticed that even though the automatic system has been developed to treat hazelnut suckers'; the protocol could be easily adapted to treat any kind of tree that develops herbaceous suckers similar in structure to the ones of the hazelnut trees as in *Prunus* spp. chestnut and olive. The system is able to significantly reduce the amount of chemicals used, thus reducing the environmental impact. Furthermore, the automated suckers management developed in PANTHEON will allow the growers to significantly reduce the costs for suckers' control when compared with manual or mechanical approaches carried out seasonally in the hazelnut orchard.

Possible economic exploitation of the obtained results (e.g. setting up a spinoff) are under investigation with the collaboration of other units.

Task 5.2 – Pruning protocol - An automatic pruning protocol has been developed within the project to provide pruning suggestions for branches of different order of hazelnut trees that do not fit agronomical safe-growing criteria such as shape, orientation, or length and health. The pruning protocol utilizes as input a 3D graph model of the tree that needs to be pruned and returns as output a graphical annotation on the branches that should be removed according to said agronomical criteria, as well as an estimation of the quantity of the wood that would be removed from the tree.

This new approach in training and pruning hazelnut trees grown in different shape forms will allow a more accurate management plant crown, promoting a more uniform and substantial light penetration into the inner portion of the tree canopy, improving the yield performance of the plants over the medium term, reducing the biennial bearing aptitude of the species and promoting more efficiency in carrying out plant protection treatments.

Furthermore, it should be noticed that even though the pruning suggestion protocol has been developed exclusively for hazelnut trees; however, the same design criteria and methods used in project, could be applied to different fruits trees, both grown as shrub or as shape-vase to obtain an equally valid pruning suggestion protocol.

5.2.5 UNITUS

Task 5.4 – Major Pests and Diseases Monitoring and Control - Both the definition of the molecular assay (qPCR) for reliable detection of the pathogen in plant tissue and the study of the influence of environmental

parameters on biological behaviors of the pathogen were aimed to provide auxiliary elucidations to the final goal of early detection of the pathogen.

In the project, the series of lab testing that have been carried out to assess the influence of temperature on the mycelial growth and on the conidial germination, constitute bricks for the development of epidemiological forecasting models for this disease, allowing a better formulation of the most appropriate control strategies for its management.

Future research on biological features of the pathogen as related to environmental variables will be addressed to complete all the modules required for a robust predictive model, capable of simulate and predict the evolution of the disease according to specific environmental conditions.

For this unit, PANTHEON was the starting point for opening new research directions, that might have a very concrete effect on the way pests and diseases are monitored and controlled.

5.2.6 SIGMA

Task 3.3 - Definition and Implementation of the Data Repository – SIGMA coordinated the definition of a large part of the database. The correct structuring of the information made it possible to facilitate the exchange of information between the various components of the system. The elements of the field and the agronomic activities have been modelled as central points to the application domain of the system. SIGMA used a No-SQL database for the first time within a project and used the JSON data format extensively.

SIGMA plans to apply in future IoT and Smart Farming projects the use of No-SQL databases for the management of recurring data, such as sensor telemetry, and to aggregate heterogeneous data, which are difficult to treat with classic relational databases. The JSON format also proved to be an appropriate choice in facilitating the exchange of information between software modules, so it will be adopted as the main data format in future software projects.

Task 3.5 – Design and Implementation of the User Interface- The user interface was developed to provide an intuitive and simple tool to view and manage all the results of the PANTHEON system, from data acquisition to decision support. The use of the application allows agronomists to manage all the activities in the field to maximize plant health, increase yield and reduce waste and pollution.

The application was developed with modern WEB technologies. The user interface is responsive, multi-device, accessible by multiple users and with different roles. Stack MEAN was used for the implementation, which ensures the development of robust, modular and product-oriented applications.

The user interface developed for the PANTHEON project has become the reference standard for Sigma Consulting regarding the design and implementation of user applications in the Smart Farming field. The same technologies provided by the MEAN standard will be used, therefore development in JavaScript language, front-end implemented in Angular, back-end in Node.js and MongoDB reference database. Layout of the panels and widgets used are easily adaptable to new Smart Farming scenarios. Many features of the Pantheon user interface can be easily reapplied even to generic IoT projects, such as the real-time display of sensor telemetry and a clear display/visualization of data via dashboard.

Task 6.2 –Integration, Testing and Field Validation of the SCADA system – The design and definition of the PANTHEON architecture made it possible to define the concepts of peripheral node (edge node) and main node (central node). The edge node deals with the collection and pre-processing of data directly in the field, while the central node deals with data processing and storage.

The management of data flows between the various components has been orchestrated / managed at the server level using the Node-Red tool, which allows direct and effective visual programming. The integration activity made it possible to implement the data exchange between the IoT sensors installed in the field and the server. In addition, the interface with the ROS operating system on the robots has been implemented.

The PANTHEON architecture will be used by Sigma Consulting as a starting point for the development of other Smart Farming products and services that the company plans to launch. Some features will be improved based on the experience gained during PANTHEON. For example, to have a system that is ready for the market, the central server must necessarily be configured in the cloud, not on its own servers as it is in PANTHEON project. In addition, for the management of the telemetry of the IoT sensors, special software will be used that independently manage the acquisition and storage of the detected data.

5.3 Recommendations to the consortium for the IP protection

This section provides a series of recommendations to the consortium regarding the IP protection of the knowledge generated during the project PANTHEON. The main measures proposed are the following:

- **Scientific contributions:** The members of the consortium are encouraged to publish all scientific contributions and results obtained in PANTHEON in order to disseminate as much as possible the scientific knowledge generated during the project. The green access policy is maintained even after the end of the project.
- **Data:** It is recommended to protect the data obtained in PANTHEON during a period of 2 years posterior to the end of the project. That action will allow the proper processing of all data and publication of the results by each unit before the release of the data to the public.
- **Software:** The software generated by the Consortium should be evaluated at the end of the project by each of the different units. Based on the exploitability of the software, different kind of copyright actions will be carried out. The units have time up to 2 years after the end of the project to ask for the protection of specific portions of the software. At the current stage the parts of software that have been asked to be protected include: the navigation layer of the robots (UNIROMA3), the management of the database and the software interface of the SCADA (UNITUS), and the algorithms for the sucker's control (jointly by UNIROMA3 and ULB).

6 Annex 1 – Publications and dissemination activities

In the following we provide a list of the scientific publications generated during the 4 years of project PANTHEON.

6.1 List of publications

6.1.1 Journal papers

[1] Stefano Speranza, Massimo Olmi, Adalgisa Guglielmino and Mario Contarini. “A new species of the genus Deinodryinus Perkins (Hymenoptera, Dryinidae) from the USA”. ZooKeys 809:31-39, 2018.

[2] Valerio Cristofori, Cristian Silvestri, Marco Paolocci, Aniello Luca Pica, Andrea Gasparri, Nadia Valentini and Roberto Botta.” Gestione agronomica del corileto nell’era della “precision farming"”. Rivista di Frutticoltura e di ortofloricoltura 10:36-44, 2019.

[3] Stefano Speranza, Massimo Olmi, Adalgisa Guglielmino and Mario Contarini. “Gonatopus jaliscanus sp. n., a new Pincer wasp from Jalisco, Mexico (Hymenoptera, Dryinidae)”. ZooKeys 818:35-42, 2019.

[4] Sebastian Lamprecht.” Pyoints: A Python package for point cloud, voxel and raster processing”. JOSS 4:990, 2019.

[5] Sebastian Lamprecht, Johannes Stoffels and Thomas Udelhoven. “ALS as Tool to Study Preferred Stem Inclination Directions”. remote sensing :36-44, 2020.

[6] Renzo Fabrizio Carpio, Ciro Potena, Jacopo Maiolini, Giovanni Ulivi, Nicolas Bono Rossello, Emanuele Garone and Andrea Gasparri. “A Navigation Architecture for Ackermann Vehicles in Precision Farming”. IEEE Robotics and Automation Letters (RA-L), 2020.

[7] Cristian Silvestri, Loretta Bacchetta, Andrea Bellincontro and Valerio Cristofori. “Advances in cultivar choice, hazelnut orchard management and nuts storage for enhancing product quality and safety: an overview”. Journal of the Science of Food and Agriculture :jsfa.10557, 2020.

[8] Matthias Pezzutto, Nicolás Bono Rosselló, Luca Schenato and Emanuele Garone. “Smart testing and selective quarantine for the control of epidemics”. Annual Reviews in Control, 2021.

[9] Nicolas Bono Rossello, Renzo Fabrizio Carpio, Andrea Gasparri and Emanuele Garone. “Information-Driven Path Planning for UAV With Limited Autonomy in Large-Scale Field Monitoring”. IEEE Transactions on Automation Science and Engineering, 2021.

[10] Luca Rossini, Nicolás Bono Rosselló, Stefano Speranza and Emanuele Garone. “A general ODE-based model to describe the physiological age structure of ectotherms: Description and application to Drosophila suzukii”. Ecological Modelling 456:109673, 2021.

[11] Stefano Speranza, Massimo Olmi, Leonardo Capradossi and Mario Contarini. “A new species of Anteon (Hymenoptera, Dryinidae) from Turkey”. Journal of Hymenoptera Research 84: 373–380, 2021.

6.1.2 Book chapters

[12] Valerio Cristofori, Stefano Speranza and Cristian Silvestri. “Developing hazelnuts as a sustainable and industrial crop”. In Burleigh Dodds Series in Agricultural Science. 2019, 465–504.

[13] Antonio Maccioni and Riccardo Torlone. "KAYAK: A Framework for Just-in-Time Data Preparation in a Data Lake". In Advanced Information Systems Engineering. 2018, 474–489.

6.1.3 Conference papers

[14] Elie Hermand, Tam Willy Nguyen, Mehdi Hosseinzadeh and Emanuele Garone. "Constrained Control of UAVs in Geofencing Applications". In 2018 26th Mediterranean Conference on Control and Automation (MED). June 2018, 217-222.

[15] Renzo Fabrizio Carpio, Letizia Di Giulio, Emanuele Garone, Giovanni Ulivi and Andrea Gasparri. "A Distributed Swarm Aggregation Algorithm for Bar Shaped Multi-Agent Systems". In IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS). October 2018, 4304-4307.

[16] Matteo Santilli, Alessandro Marino and Andrea Gasparri. "A Finite-Time Protocol for Distributed Continuous-Time Optimization of Sum of Locally Coupled Strictly Convex Functions". In 2018 IEEE Conference on Decision and Control (CDC). December 2018, 993-998.

[17] Tigran Fahradyan, Nicolas Bono Rossello and Emanuele Garone. "Multiple Carrier-Vehicle Travelling Salesman Problem". In International Conference on Modelling and Simulation for Autonomous Systems - MESAS 2019. October 2019.

[18] Nicolas Bono Rossello, Renzo Fabrizio Carpio, Andrea Gasparri and Emanuele Garone. "A novel Observer-based Architecture for Water Management in Large-Scale (Hazelnut) Orchards". In AgriControl 2019, 6th IFAC Conference on Sensing, Control and Automation Technologies for Agriculture. December 2019.

[19] Nicolas Bono Rossello and Emanuele Garone. "Carrier-vehicle system for delivery in city environments". In 21th IFAC World Congress. January 2020, 15253–15258.

[20] Ciro Potena, Renzo Fabrizio Carpio, Nico Pietroni, Jacopo Maiolini, Giovanni Ulivi, Emanuele Garone and Andrea Gasparri. "Suckers Emission Detection and Volume Estimation for the Precision Farming of Hazelnut Orchards". In 2020 IEEE Conference on Control Technology and Applications (CCTA). August 2020,

[21] Martina Lippi, Niccolò Bonucci, Renzo Fabrizio Carpio, Mario Contarini, Stefano Speranza and Andrea Gasparri. "A YOLO-Based Pest Detection System for Precision Agriculture". In 2021 29th Mediterranean Conference on Control and Automation (MED). June 2021, 342-347.

[22] Renzo Fabrizio Carpio, Jacopo Maiolini, Ciro Potena, Emanuele Garone, Giovanni Ulivi, Andrea Gasparri "MP-STSP: A Multi-Platform Steiner Travelling Salesman Problem Formulation for Precision Agriculture in Orchards", In the international conference IEEE International Conference on Robotics and Automation, June 2021

[23] Nicolas Bono Rossello, Matthias Pezzutto, Luca Schenato, Iganzio Castagliuolo and Emanuele Garone "On the effect of the number of tests and their time of application in tracing policies against COVID-19". In the 11th IFAC Symposium on Biological and Medical Systems, September 2021.

[24] Matteo Santilli, Renzo Fabrizio Carpio and Andrea Gasparri. "A Framework for Tasks Allocation and Scheduling in Precision Agriculture Settings". In the 20th International Conference on Advanced Robotics (ICAR), December 2021. (Submitted)

[25] Martina Lippi, Renzo Fabrizio Carpio, Mario Contarini, Stefano Speranza and Andrea Gasparri "A Data-Driven Monitoring System for the Early Detection of Pest Infestations in the Precision Agriculture of Hazelnut Orchards". In the 20th International Conference on Advanced Robotics (ICAR), December 2021. (Submitted)

6.1.4 Extended abstracts

[26] Nicolas Bono Rossello, Emanuele Garone, Andrea Gasparri and Renzo Carpio. "A Supervisory Control And Data Acquisition (SCADA) system in agriculture and related path planning problems". In 37th Benelux Meeting on Systems and Control. March 2018.

[27] Mario Contarini, Valerio Cristofori, Cristian Silvestri, Luca Rossini, Andrea Gasparri, Emanuele Garone, Thomas Udelhoven, Rebecca Retzlaff, Sebastian Lamprecht, Emanuele Graziani, Michela Pecchia, Laura Giustarini, Cristina Carletti, Gianni Ulivi, Riccardo Torlone, Alessandro Albino Frezza and Stefano Speranza. "PANTHEON (Precision Farming of Hazelnut Orchards) for the improvement of integrated pest management (IPM) effectiveness". In 70th International Symposium on Crop Protection. May 2018.

[28] Valerio Cristofori, Stefano Speranza, Cristian Silvestri, Mario Contarini, Leonardo Varvaro, Andrea Gasparri, Emanuele Garone, Thomas Udelhoven, Rebecca Retzlaff, Sebastian Lamprecht, Emanuele Graziani, Michela Pecchia, Laura Giustarini, Daniele Galli, Cristina Carletti, Giovanni Ulivi, Riccardo Torlone and Alessandro Albino Frezza. "PANtHEOn-precision farming in hazelnut orchards". In Acta Italus Hortus XII giornate Scientifiche SOI. June 2018.

[29] Mario Contarini, Valerio Cristofori, Cristian Silvestri, Luca Rossini, Leonardo Varvaro, Andrea Gasparri, Emanuele Garone, Thomas Udelhoven, Rebecca Retzlaff, Sebastian Lamprecht, Emanuele Graziani, Michela Pecchia, Laura Giustarini, Cristina Carletti, Giovanni Ulivi, Riccardo Torlone, Alessandro Albino Frezza and Stefano Speranza. "PANTHEON (Precision Farming of Hazelnut Orchards) for the improvement of integrated pest management (IPM) effectiveness". In XI European Congress of Entomology. July 2018.

[30] Andrea Gasparri, Giovanni Ulivi, Nicolas Bono Rossello and Emanuele Garone. "The H2020 project Pantheon: precision farming of hazelnut orchards". In Convegno Automatica. September 2018.

[31] Nicolas Bono Rossello, Emanuele Garone, Andrea Gasparri and Renzo Carpio. "Information-Based Path Planning for UAV Orchard Coverage". In 38th Benelux Meeting on Systems and Control. March 2019.

[32] A. Grottoli, S. Turco, L. Faino, M. Reverberi, V. Cristofori, A. Mazzaglia. "Draft genome sequence of a new Fusarium isolate collected from hazelnut in central Italy." European Fusarium Seminar. June 2021.

[32] M.I. Drais, A. Faluschi, S. Turco, L. Varvaro, V. Cristofori, A. Mazzaglia. "Morphological, physiological and molecular characterization of Monostichella coryli, the causal agent of hazelnut anthracnose." XXVI SIPaV Congress 2021. September 2021.

[33] A. Grottoli, S. Turco, L. Faino, M. Reverberi, V. Cristofori, A. Mazzaglia. "Draft genome sequence of a new Fusarium isolate collected from hazelnut in central Italy." XXVI SIPaV Congress 2021. September 2021.

[34] A. Grottoli, S. Turco, L. Faino, M. Reverberi, V. Cristofori, A. Mazzaglia. "Draft genome sequence of a new Fusarium isolate collected from hazelnut in central Italy." Nanopore Community Meeting. December 2021.

6.2 Dissemination activities

6.2.1 Press Releases and Institutional Websites

1. Press Release and publication on the FERRERO Hazelnut Company.
2. Press Release and publication on the website of remote sensing department at TRIER university.
3. Press Release and publication on the website of remote sensing department at TRIER university.

4. Press Release and publication on the remote sensing department at ACT'ULB (official research communication of ULB).
5. Press release on the SAAS department of ULB. In evidence on the home page of the department for more than 6 months.
6. Press Release UNITUS
7. Webpage department DAFNES at UNITU
8. Publication on two pages of the Sigma institutional website
9. Press release and publication on the DEI department of UNIROMA3
10. Description of the PANTHEON project in Sigma website
11. Sigma communication of their Facebook webpage

6.2.2 Mass Media

1. Publication on the Intraletters of ULB.
2. 30th of December 2017, PANTHEON is mentioned on a national newspaper Il Messaggero
3. 19th of January 2018 Interview on PANTHEON on the GRUNITUS RADIO
4. 21st of January 2018, Regional online newspaper TusciaUP
5. 23rd of April 2018, Andrea Gasparri (UNIROMA3) was interviewed on PANTHEON on Radio RomaTre (UNIROMA3 university radio)
6. Article on RadioRoma Capitale
7. August 2019, PANTHEON was featured on Euronews.
8. January 2021, PANTHEON was featured on VTV2 (Vietnam national TV).
9. May 2021 Italian national Interview with "Corriere della Sera"

6.2.3 Popular Science and Technology Media

1. 8th of January 2018, e-gazette.it
2. March 2020, PANTHEON project appeared in section research and innovation of the March 2020 issue of the Italian magazine Platinum business leaders.

6.2.4 Participations to fair and events

1. 13th-15th of March 2018, Participation to the European Robotic Forum
2. April 2018, Participation to the Fair Fidae (international air and space fair)
3. 29th-30th of November 2019, Participation to the 6° international business convention for the aerospace industry in Torino (Sigma)
4. 28th September 2019, Participation to the "Notte Europea dei Ricercatori" in Rome
5. 13th of October 2018, Participation to the MAKER FAIR ROME
6. 15th-17th of March 2019, The ULB unit participated to the Dronedays with an ULB stand featuring PANTHEON
7. 2nd-8th of July of 2019, Participation at Drone world congress in Shenzhen in China with multiple activities
8. 17th-18th of October 2019, Participation to the MAKER FAIR ROME
9. 13th of April 2021, Invited talk by Andrea Gasparri at the workshop "HORIZON2020 Robotics Projects: Success Stories.
10. 14th of April 2021, invited talk by Andrea Gasparri at the workshop "Agri-food: AI and robotics in agri-food: the present and the future", organized by Sarah Terreri at European Robotics Forum (ERF).
11. 23rd of June 2021, Presentation of the results of the project PANTHEON to the EU Commission President.

12. 20th of September 2021, Talk by Martina Lippi for the European Researchers' Night at Roma Tre University.

6.2.5 Communication toward Hazelnut farmer

1. 28th of June 2017 Internal email to the management of the FERRERO group
2. 9th of May 2018 Ferrero AgroInnovation extended committee
3. Article in Coricoltura sostenible in Piemonte
4. June 2021. Article at the Information Bulleting of the Research Network on Nuts

6.2.6 Dissemination toward General Farmers Networks and Associations

1. 21st of December 2017, Unione Coltivatori Italiani
2. 22nd October 2018, article from the newspaper "ITALIAFRUIT NEWS"
3. 2nd of July 2021, Invited talk at Convegno Confagricoltura Umbria

6.2.7 Dissemination toward National Organizations for Industrial and Research Development

1. 11th of December 2018 – Stati Generali of Agriculture in Lazio Region
2. DIGINNOVE
3. Presentation of 'PANTHEON project: UAV path planning for agricultural monitoring' at the ID2Move Academic Seminar on Autonomous Systems
4. Presentation of PANTHEON project at the ID2Move for the president and management of the UAV World Federation and the officers of the Waloon Region for spin-offs and industrial research.
5. 18th of December. Sigma consulting presented the PANTHEON project at the Open Day Atens, which is a Network of Companies from Tecnopolo Tiburtino and Lazio and consists of 42 companies, 4 institutes and research bodies.

6.2.8 Scientific Workshop

1. Workshop organized at the CCTA 2020
2. Workshop "Control, Robotics, Sensing and Artificial Intelligence for Precision Agriculture" at the 2021 29th Mediterranean Conference on Control and Automation (MED)

6.2.9 Dissemination toward Companies

1. ULB communicated the concept of Pantheon in a number of meetings with four companies
2. During 2018, SIGMA had the opportunity to present PANTHEON to 4 leading company in agrifood sector

6.2.10 Dissemination toward Students

a. Primary and Secondary School students
    i. 4th of May 2018 UNITUSCIA unit gave a short lesson in a primary and secondary school in La Plata (Argentina) “Escuela Italiana EP con curso preescolar” showing the future of agriculture through PANTHEON.
b. Agriculture related Universities and Faculties
    i. 23rd of January 2018. The TRIER team presented PANTHEON at the Department of Remote Sensing and Geoinformatics of Trier University. Several professors and students of environmental science participated in the colloquium.

ii. 7th of May 2018, UNITUSCIA has presented the activities of Pantheon within the framework of a meeting between their unit and the Faculty of Agriculture and Farming of the Universidad Nacional de Cuyo, Mendoza, Argentina,
iii. PANTHEON presentation to international students for "With Robotics in the Future" (Erasmus +)
iv. 19th of February 2019: Lecture by Andrea Gasparri on February 19th (half day) during the Master course in Precision Agriculture organized by Università della Tuscia. The lecture dealt with ground robotic platforms for Precision Agriculture.

c. Engineering Faculties
   i. 4th-5th of December 2017 UNIROMA3 unit presented the Pantheon project to the students of the Robotics class in two different lectures. In one lecture they presented the concept of PANTHEON, in the next lecture, they used PANTHEON as a case study for a lecture on ROS.