This project is funded by the European Union
G.A No 101016906

Project Number: 101016906
Start Date of Project: 2021/01/01
Duration: 48 months

Type of document D1.4 – V1.0

Risk Assessment and Contingency Plan

Dissemination level	CONFIDENTIAL
Submission Date	2021-04-30
Work Package	WP1
Task	T1:1
Type	Report
Version	1.0
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Approved by	PMC

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Executive Summary

This deliverable provides the detailed plan for the constant monitoring of proper synchronization of the partners contributions and of the project activities so to respect the project timeline, to assess actual risks and anticipate future criticalities by proposing adequate countermeasures and mitigation actions.

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Table of Content

Abbreviations and Acronyms

CO	Coordinator
EC	European Commission
PMC	Project Management Committee
IPR	Intellectual Property Rights
WP	Work Package
PO	Project Officer
BEM	Box-Exchange Mechanism
VR	Virtual Reality
GA	Grant Agreement

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1 Risk Analysis and Contingency Plan

1.1 Safety Risks

1.1.1 Achieving a Safety Risk Assessment Sufficient to Allow Full Trials

Risk	Low	Achieving a safety risk assessment sufficient to allow full trials
Problem Description		Assessment of risks and hazards does not allow collaborative working near the cutting tool or the robots while navigating.
Impact		High
Mitigation and Contingency Plan		Only directly involved partner staff will be allowed within range of the robots while they are working. Moreover, as precaution measures during operation, all partner staff will be equipped with appropriate safety gear, i.e., safety glasses, reflective shirts, and safety shoes. Trials will be performed in an environment closed to the public and vineyard employees. Operational speed of the robot will be limited to 250mm/s for the robotic arms and 0.3 m/s for the mobile base, thus making it easier to activate emergency stops. The identified mobile base Alitrak DCT-350P, comes equipped with embedded wireless emergency stop, that will cause the interruption of power to all on-board components. More emergency stops are going to be placed in several easy to reach positions in the robotic arms and mobile base. If the risk to humans is still considered too high or in the unlikely event of an actual injury, then collaborative working can be imitated to some extent by faking the parallelism -- freezing the robot when the human is within range and resuming when they leave. In case of an injury, proper treatment will be reached immediately. The Consortium has identified all first aid establishments close to the trial fields. Legal liability will burden the partner which staff was injured.

1.2 Technological Risks

1.2.1 Integration Delays of Hardware and Software Robotic Components

Risk	Medium	Integration Delays of Hardware and Software Robotic Components
Problem Description		The hardware and software robotic components developed by the partners are delayed and cannot be integrated, thus inducing a delay in the scheduling of the research and experimental activities.
Impact		High
Mitigation and Contingency Plan		Since this is a research project, some delays either on development or integration are expected. Knowing that, we devise mitigation measures that include all the aspects regarding delays on the integration of robotic components. In regard to specifications, in WP2 we define that any specifications will be amended, and corrections will be performed. Despite the conservative dimensioning of system components, we will also combat any possible delays with extra effort. Regarding integration delays emerging from hardware components, in T3.1 we define that hardware must be easy to replace so that other choices can be explored. In the case that the hardware stops functioning properly, we will switch it with one from another robot or even switch the robot prototype. We already include shipping costs so that prototypes and other components will be shipped either to DTI or hardware supplier or manufacturer for repairs. In case that the hardware is custom, i.e., developed end-effectors, agronomic dual arm setup, BEM, more effort will be put to redesign, replicate and replace the component. Regarding delays from software components on the robot, all members of the consortium are experienced with robotic software and they have already identified a common middleware that will assist with software integration, i.e., ROS. In the case that software is not performing properly, it will be replaced with an older working version. If there is no older version, then we will increase the effort to cover the potential delays. In case of any of the above, we will inform the PO about potential delays in our experiments. In the case of additional effort that is not cover by the original WP budget, then we will reshuffle budgets from other tasks.

1.2.2 Delays on the Integration of Complementary System Components

Risk	Medium	Delays on the Integration of Complementary System Components
Problem Description		Core functions of the proposed system are based on complementary components, i.e., VR components for HRI and on-field network infrastructure for MRC.
Impact		High
Mitigation and Contingency Plan		For on-field networking we will use a market-ready solution that will require a minimum amount of intervention and setup on the vineyards. In the case of hardware or software integration delays, then more effort will be put to get the equipment in an operational state. In the case of delays on the integration on the VR components then associated partners will increase their effort in order to meet the project goals. The PO will be informed for potential delays in the experimental process. The WP budget will be amended and redistributed to cover the need for the extra effort, if needed.

1.3 Experimental Risks

1.3.1 Unexpected Event Delays Running Experiments

Risk	High	Unexpected event delays running experiments
Problem Description		Minor failures and inefficiencies are inevitable and time to fix these is built into the field trial timetable. Large problems, e.g., a robot falling and sustaining significant damage are much less likely, but also much more impactful.
Impact		Medium
Mitigation and Contingency Plan		Time for delays for hardware repairs can normally be recovered by extending the trials period. For each type of robots, two instances of the prototype will be developed. Indeed, this intrinsically introduce a valuable level of redundancy that may help mitigating unexpected failures of the robotic prototypes, as apart from the research activities focused on the multi-robot coordination, for which all these units are expected to be used (considered only in WP7), all the other research activities focus on HRI and HRC between one robotic unit and one human operator. These copies are intended to enable continuous improvements, while field trials are ongoing, but can be diverted at need. Shipping takes time so it is only worthwhile early enough in the season. If software issues or algorithmic functionalities jeopardize the experimental process, then the component will be removed, and its functionality faked. Serious damage or software failures will cause significant delay and even termination of an experiment, so we would talk to the Project Officer about possible extensions and where to focus our remaining effort.

1.3.2 Project Delays Cause Robot Trials to Miss an Upcoming Field Validation Season

Risk	High	Project delays cause robot trials to miss an upcoming Field Validation season
Problem Description		Research and technological developments may take longer than expected and cause delay in starting field trials.
Impact		Medium
Mitigation and Contingency Plan		The human-robot teams have tasks in two seasons: harvesting in May to September and pruning in December and January. Therefore, the longest gap between available tasks is three months. CANOPIES activities have been planned over 4 years to comply with seasonal constraints and ensure that there is flexibility to accept a season of delay in the validation of the main system functionalities. In the case of an upcoming cancelation of one of the field validations, due to delays to either the research or technological developments or other

	extreme conditions, the Consortium will inform the PO. Then, the experimental process will be instead performed in the facilities of one of the local Consortium partners. All the functionalities that cannot be tested will be performed in the next Field Validation season (or final demonstration if the delays are close to the end of the project).

1.3.3 Project Not Reaching the Final Demonstration

Risk	Low	Project not reaching the Final Demonstration
Problem Description		Due to development issues during the project the final integration and demonstration is not possible.
Impact		High
Mitigation and Contingency Plan		Potential final integration and demonstration issues would become evident during the project. With our revisions and rolling experimental validation we expect to find potential issues early, bring those issues to the attention of the PO and perform the defined safety, technological, research and experimental mitigation actions. If for any reason we are unable to perform a demonstration during one of the experimental seasons, i.e., harvesting season, all robot functionalities are going to be presented in the next one. If due to imponderable conditions the experiments cannot take place in Italy, then the experiments will be performed in one of the countries of the participating partners. In the case that we find out that some aspects of the project are beyond the capabilities of the Consortium, we will seek extra experts and bring them to the consortium, i.e., making all required amendments to the proposal. If major project objectives are not met, then we will apply for a project extension, in coordination with the PO, providing a full report on the issues and agreed amendments to the project objectives.

1.4 Research Risks

1.4.1 Multi-Robot Online Task Re-Planning

Risk	Low	Multi-Robot Online Task Re-Planning
Problem Description		Temporal logic plans for multi-agent systems are subject to high computation times as a function of the number of agents. Despite efforts to reduce computation times, they may still hinder the overall online re-planning strategy depending on the number of robots in the system.
Impact		Medium
Mitigation and Contingency Plan		We will provide a trade-off between computational effort and number of robots in the workspace. Should the required number of robots for the agronomic objective be in excess, the workspace can be decoupled into independent workspaces to ensure computational effort demands are met.

1.4.2 Multi-Robot Coordination Strategies

Risk	Low	Multi-Robot Coordination Strategies
Problem Description		The challenging constraints on the multi-robot communication model may affect the development of effective distributed coordination strategies for typical PA settings.
Impact		Medium
Mitigation and Contingency Plan		We will approach the design problem by starting from a simplified, and yet realistic, working scenario by assuming a communication network to be available and then we will try to release one by one the simplifying working conditions in order to move towards a more realistic scenario where the availability of a network infrastructure is no longer required. In the case, under these limiting assumptions, effective protocols could not be designed, we will focus our research on the design of a hybrid solution where reasonably only a minimal network infrastructure is required.

1.4.3 Discrepancies Between the Virtual Reality Environment and the Real Robot Setup

Risk	Medium	Discrepancies between the virtual reality environment and the real robot setup
Problem Description		The dynamics of the task and the visual appearance of the objects in the virtual reality environment can be very different than the real world. This affects the possibility of transferring knowledge from the virtual reality environment to the real physical setup.

Impact	Medium
Mitigation and Contingency Plan	This issue can be mitigated in several ways: (1) early and often prototype deliveries from consortium partners as source information for the virtual environment, (2) presentation of prototype deliveries to partners for feedback on discrepancies between the virtual environment and the robot setup, (3) developing advanced domain adaptation techniques based on domain randomization to facilitate the adaptation from simulation to the reality even with a considerable amount of discrepancies between the simulation and the reality, and (4) training the models in a mixed reality environment. The robots can be developed without the VR using traditional methods.

1.4.4 Failed Detection and Localization of Vine Branches

Risk	Medium	Failed detection and localization of vine branches
Problem Description		The detection of vine branches that obstruct the harvesting of grapes or the pruning process, is a complex problem that can fail in some cases, causing damage and therefore financial loss.
Impact		Medium
Mitigation and Contingency Plan		We will fuse information from different sensors to solve this problem, but in case that is not possible we will combine joint manipulation and perception. Another possible solution is to ask for human help thanks to the human-robot-interaction methodologies developed within the project. Anyway, it is possible that the reaction time will be lower than expected, but this is not a real issue for the objectives of the project. For this research solution, we can get the robot to shine a light where it would cut, instead of actually cutting. This would allow us to evaluate the decision about the cutting location without any damage being done.

1.4.5 Failures in Human Body or Arm Location and Orientation Prediction

Risk	Medium	Failures in human body or arm location and orientation prediction
Problem Description		When we cannot observe the human joints, predicting future location and orientation can fail. This has significant consequences for human safety and therefore also for the robot risk assessment and our authorization to operate.
Impact		Medium

Mitigation and Contingency Plan	We will combine different sensors and from different point of view to overcome this problem; however, this could not be enough. Then, we will use the help of the human to overcome some of these situations by using an interface through which the robot can immediately communicate the problem to the human and use recovery techniques to solve the problem. A reduced version of field trials can still take place while human safety is insufficiently assured by time-slicing the activity to fake parallel collaborative action. When time-slicing, the human retreats out of range while the robot does something, then the robot freezes (stops) while the human comes close and does their part of the task. These retreats will result in very slow action that is nevertheless meaningful in terms of research results.

1.4.6 Network Synchronization of the Simulation Participants

Risk	Medium	Network synchronization of the simulation participants
Problem Description		Network-based synchronization of the physical movements occurring at different peers is inherently complex and can lead to movement not being in sync.
Impact		Medium
Mitigation and Contingency Plan		We will utilize network ownership transfer principles and make a selection between client- and server-centric authority to secure the right functionality early in the project. Networking synchronization framework will be tested for their relevance to this project, and the best-fit framework will be used in the project foundation.

1.5 Management, Dissemination and IPR Risks

1.5.1 Partner Underperforming

Risk	Low	Partner Underperforming
Problem Description		Project management issues that lead to delays, improper quality or mediocre impact as a result of a broad and complex scope and partners being different in nature and focus
Impact		Medium
Mitigation and Contingency Plan		All the partners have good track-records and several groups within the consortium have already collaborated in the past. The project has set up a proven management structure with experienced partners assisted by the PMC that supports in monitoring the achievement of impact and progress. Although the consortium is set up complementary in nature, there is some overlap in expertise to help one another out in case needs arise. The project has well-defined deliverables and milestones to monitor progress and impact and to give feedback in case unlikely of under-performance. In the extreme case of a partner underperforming on a regular basis, actions will be taken accordingly to the Consortium Agreement.

1.5.2 Partner Default

Risk	Low	Partner Default
Problem Description		One of the consortium partners is in default. This may cause severe delays in the project activities.
Impact		High
Mitigation and Contingency Plan		This occurrence seems very unlikely given the solidity of the consortium, the commitments of the partner and the existence of previous collaborations. Should a partner be in default, the CO will promptly inform the PO and, assisted by the WP leaders and the PMC, shall provide within 30 days a contingency plan envisaging either the opening of a call for integrating the consortium with a new partner being technically skilled as the defaulted one, or reshaping the workplan and distributing the workload among the participating entities.

1.5.3 Tasks Execution Issues

Risk	Low	Tasks Execution Issues
Problem Description		Delays in work or lack of ability to perform the tasks as set out in the proposal
Impact		Medium
Mitigation and Contingency Plan		The CO will insist on committed timetables for deliverables and monitor progress. Routines for early warnings in the case of potential delays will be established. The PMC will sanction partners if deliverables are not completed in a timely manner.

1.5.4 Deliverables Issues

Risk	Low	Deliverables Issues
Problem Description		The quality of the deliverable is insufficient. This may affect the overall quality of the project and the capability to perform high-quality dissemination activities.
Impact		Low
Mitigation and Contingency Plan		An internal quality review system is established for reviewing of all deliverables. The PMC will actively contribute with feedback to intermediate project results which will also benefit the deliverables

1.5.5 Problems in the Dissemination and Promotion of Results

Risk	Low	Problems in the dissemination and promotion of results
Problem Description		Ineffective Dissemination which may lead to a low-visibility of the project results.
Impact		High
Mitigation and Contingency Plan		All the partners are strongly involved in dissemination and communication activities in the national and international context. For this reason, the risk of an ineffective dissemination of the outcomes of the project is very low. A detailed dissemination strategy has been outlined in the Section 2 of the Annex 1 – Part B of the GA, together with continuous monitor mechanisms. Should communication/dissemination be inadequate, the partners will be encouraged to be more active in these activities. In the unlikely case of inadequate communication, the possibility to hire communication specialists (journalists, promotion agencies) will be evaluated.

1.5.6 IPR Related Problems

Risk	Low	IPR Related Problems
Problem Description		Conflicts in the attribution of the intellectual properties which may affect the exploitation of the results.
Impact		High
Mitigation and Contingency Plan		A further planned risk is associated to a disagreement among the partners about the ownership of the foreground and related IPR problems. To minimize possible occurrence of IPR problems, clear IPR-rules and conflict resolution procedures will be specified the Consortium Agreement. Joint ownership will be encouraged. Further possible problems will be managed by strengthening the discussion among the partners and by possibly involving an IPR expert.

1.6 Overview of the risks

Here an overview of all the considered risks along with the respective involved WPs.

ID	Risk	Type	Level	Involved WPs
1.1.1	Achieving a safety risk assessment sufficient to allow full trials	Safety	Low	6
1.2.1	Integration Delays of Hardware and Software Robotic Components	Technological	Medium	3,5
1.2.2	Delays on the integration of Complementary System Components	Technological	Medium	3,7
1.3.1	Unexpected event delays running experiments	Experimental	High	3,9
1.3.2	Project delays cause robot trials to miss an upcoming Field Validation season	Experimental	High	All
1.3.3	Project not reaching the Final Demonstration	Experimental	Low	All
1.4.1	Multi-Robot Online Task Re-Planning	Research	Low	8
1.4.2	Multi-Robot Coordination Strategies	Research	Low	7
1.4.3	Discrepancies between the virtual reality environment and the real robot setup	Research	Medium	3,4,5,6,7,8
1.4.4	Failed detection and localization of vine branches	Research	Medium	4
1.4.5	Failures in human body or arm location and orientation prediction	Research	Medium	6
1.4.6	Network synchronization of the simulation participants	Research	Medium	3,4,5,6,7,8
1.5.1	Partner Underperforming	Management, Dissemination and IPR	Low	All
1.5.2	Partner Default	Management, Dissemination and IPR	Low	All
1.5.3	Tasks Execution Issues	Management, Dissemination and IPR	Low	All
1.5.4	Deliverables Issues	Management, Dissemination and IPR	Low	All
1.5.5	Problems in the dissemination and promotion of the results	Management, Dissemination and IPR	Low	10
1.5.6	IPR Related Problems	Management, Dissemination and IPR	Low	All